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SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB.  
VOLUME 5: LIFE SCIENCES LABORATORY SYSTEM  
REQUIREMENTS DATA BOOK. BOOK 3: PRELIMINARY  
EQUIPMENT ITEM SPECIFICATION (General

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## DEFINITION OF LIFE SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB

BOOK 3 • PRELIMINARY EQUIPMENT ITEM  
SPECIFICATION CATALOG

**GENERAL DYNAMICS**  
*Convair Division*



REPORT NO. CASD-NAS-75-054

# **DEFINITION OF LIFE SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB**

**VOLUME V + LIFE SCIENCES LABORATORY SYSTEM  
REQUIREMENTS DATA BOOK**

**BOOK 3 + PRELIMINARY EQUIPMENT ITEM  
SPECIFICATION CATALOG**

**December 1975**

**Submitted to  
National Aeronautics and Space Administration  
GEORGE C. MARSHALL SPACE FLIGHT CENTER  
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**Prepared by  
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## PRELIMINARY EQUIPMENT ITEM SPECIFICATION CATALOG

This volume includes working data on the equipment items (E.I.s) within the Life Sciences Laboratory Common Equipment Inventory. Section 1 contains a set of E.I. Disposition Work Sheets, and Section 2 contains specification work sheets on the major E.I.s in the inventory.

The Disposition Work Sheets are based upon the initial list of E.I.s and their categories (Regular, Intermittent, or P.I.) submitted to Convair by NASA at the beginning of the current life sciences study. The list was entitled "Life Sciences Core Inventory (LSWG, April 1974)", and was dated January 1975. During the course of the current study, E.I.s were renamed, renumbered, recategorized, deleted, etc. The disposition work sheets summarize these changes and reflect the final E.I. inventory.

The final Common Equipment Inventory is tabulated in Section 2. Additionally, those items of major importance (rated Regular or Intermittent, see Section 1 for definitions) are described in further detail in preliminary specification sheets. These sheets describe the E.I.s and include data on their weight, power and volume. They make up the major portion of Section 2.0 and of this Volume.

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## **SECTION 1**

### **EQUIPMENT ITEM DISPOSITION WORKSHEETS**

## SECTION 1

### EQUIPMENT ITEM DISPOSITION WORKSHEETS

The following tables contain information on the disposition of the equipment items (E.I.s) originally submitted to Convair by NASA at the beginning of the current life sciences study. The list submitted was entitled "Life Sciences Equipment Core Inventory" (LSWG, April 1974), January 1975. Some E.I.s have been added and the reasons for these additions have been documented.

#### Definitions and Abbreviations for Disposition Sheets

E.I. = Equipment Item.

E.U. = Equipment Unit.

In = E.I. retained in inventory listing.

Out = E.I. no longer identified as a separate item in the inventory (item was either deleted, combined within another E.I. such as a kit, moved to another E.U., or renamed and assigned a new number).

The equipment which will be used in future spacecraft life sciences research has been divided into several categories depending upon who is responsible for providing that equipment. The three major divisions are: (1) equipment to be made available through the NASA life sciences laboratory development activities, (2) equipment which will be made available as a result of the U.S./ESRO Spacelab development, and (3) equipment which is specific to individual experiments and will be provided by the principal investigators (P.I.) associated with those experiments. The first category has been further divided into two groups depending upon whether the equipment is of primary or secondary importance to the pursuit of life sciences research. All four categories of equipment are defined below.

Reg. = Regular. These E.I.s are regularly required in the pursuit of life sciences research in space. Thus, they will be required early in the flight program and should receive immediate attention to determine what actions are necessary to make them available early in the life sciences laboratory development program.

Int. = Intermittent. E.I.s in this category are expected to be required on an intermittent basis. Their development or procurement is of secondary importance compared to the regular E.I.s.

- S.L. = Spacelab. These E.I.s are available as mission-dependent Spacelab equipment. This equipment must be specified as required in order for Spacelab to carry it on any individual flight. For this reason, it has been retained in the inventory. Other Spacelab equipment which will always be present such as the crew ECS or the rack structures have not been included in the inventory.
- P.I. = Principal Investigator. E.I.s with this designation are considered to be specific to individual experiments. The equipment items are expected to be part of the experiment equipment. These items are carried in the inventory to be representative only.

E.I./EU Name & Number	Dispo- sition	Cate- gory***	Comment
<u>E.U. #1 - Visual Records and Microscopy</u> <u>Original NASA EIs*</u>			
3C Adapters, TV Microscope	Out	Reg.	Included in Microscope Accessory Kit, Compound (EI 126J, EU 1)
32 Camera, Cine	In	Reg.	
32A Camera Controller	In	Reg.	
34 Camera, Still 35 mm & Strobe	In	Reg.	Changed E.I. number from 34 to 36 to conform to uniform NASA (and parallel contractor's) numbering
37 Camera, Video, B/W	In	Reg.	
38 Camera, Video, Color	In	Reg.	
38A Camera, X-Y Drive	Out	Reg.	Function will be accommodated by the Holding Unit, Small Vertebrate (40/103). (EI 103, EU 40)
76C Film	In	Reg.	
116 Log Books	In	Reg.	
126 Microscope, Compound	In	Reg.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory**	Comment
- Microscope, Com- pound, Accessory Kit	In	Reg.	E.I. number 12C assigned. Name changed to Microscope Accessory Kit, Compound.
126G Monitor, Video	Out	S.L.	Moved from E.U. 1 to Data Management Unit, E.U. 2. Changed category from regular to S.L.
134B Paper, Recording	In	Reg.	
150A Recorder, Multi- Channel Biomedical	In	Reg.	Name changed in Recorder, Strip Chart.
181E Video ID Date- Time System	Out	Reg.	Function provided by Camera Controller (EI 32A, EU 1)
- Camera, Polaroid <u>Contractor Added E.I.s**</u>	In	Reg.	E.I. number 33 assigned.
38B Camera Mounts	In	Reg.	For mounting and positioning video and 35 mm cameras.
38D Camera Timer, Video	In	Int.	Switching device to control video cameras.
75F Film, Polaroid	In	Reg.	Film for Polaroid Cameras (EI 33, EU 1 and EI 132, EU 2)
76C Film, 35 mm	In	Reg.	Film for 35 mm Camera (EI 36, EU 1)
114E Lamp, Portable Hi Int. Photo	In	Reg.	Floor lamp for photographic data acquisition.
<b>EU #2 - DATA MANAGEMENT</b>			
<u>UNIT</u> <u>Original NASA E.I.s*</u> 14B Antennas, Asst.	In	Int.	

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\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
51	Computer, Digital	In	S. L.	Part of Spacelab CDMS. Changed category from regular to S. L.
56A	Data Mgmt. Sys. Buses	In	S. L.	Part of Spacelab CDMS. Changed category from regular to S. L.
56	Data Mgmt. Sys. Plotter/Printer	Out	Reg.	Function provided by Recorder, Strip Chart (EI 150A, EU 1) or Oscilloscope and Camera (EI 132, EU 2).
58A	Data Mgmt. Sys. Remote Control Station	In	S. L.	Part of Spacelab CDMS. Name changed to Data Management System Control and Display Station. Category changed from regular to S. L.
58B	Data Mgmt. Sys. Remote Instru. Module	In	S. L.	Part of Spacelab CDMS. Name changed to Data Management System Remote Acquisition Unit (RAU). Category changed from regular to S. L.
68B	Display - Keyboard Portable	In	Reg.	This E. I. is considered a candidate for a change to the category of intermittent or P. I.
132	Oscilloscope	In	Reg.	Name changed to Oscilloscope and Camera (special camera required).
150D	Receiver	Out	Reg.	Biotelemetry receiving is provided by Electrophysiology Receiver (EI 65C, EU 12) and Receiver (EI 150B, EU 42)
153	Recorder, Voice	In	Reg.	
156	Signal Conditioner (Coupler)	In	Reg.	The terms "signal conditioner" and "coupler" are used interchangeably in the equipment inventory.

\* Original E. I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E. I. s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E. I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
176	Tape, Video	In	S.L.	Changed category from regular to S.L. Tape will be the same as that used on Spacelab video recorder.
180	Timer, Event	In	Reg.	
64	ECG Coupler	In	Reg.	Changed category from intermittent to regular.
65	EEG Coupler	In	Reg.	
66	EMG Coupler	In	Reg.	
138A	Photocells	Out	Reg.	Placed into Kit, Vertebrate Management (EI 114B, EU 42), and in Kit, Plant Management (EI 111, EU 51)
138B	Phototransistor (Coupler)	In	Reg.	Name changed to Photocell Coupler.
143G	Coupler, Pressure	In	Reg.	Name changed to Pressure Coupler
181D	Transducer, Pressure	In	Reg.	
<u>Contractor Added E.I.s**</u>				
31	Calculator, Pocket	In	Reg.	For manual calculations.
63C	Display, Numeric	In	Reg.	For local data readout.
126G	Monitor, Video	In	S.L.	Moved from Visual Records and Microscopy Unit, E.U. 1, to Data Management Unit, E.U. 2. Provided by Spacelab. Changed category from regular to S.L.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory	Comment
182T Video Tape Recorder	In	S. L.	Provided by Spacelab.
<u>EU #3 - L/S EXPERIMENT SUPPORT UNIT</u>			
<u>Original NASA E.I.s*</u>			
1 Accelerometer (10 <sup>-4</sup> g)	In	Reg.	Name changed to Accelerometer.
1A Accelerometer, Coupler	In	Reg.	
55A Crew Mobility Aids	In	S. L.	Provided by Spacelab. Changed category from regular to Spacelab.
55B Crew Restraints	In	S. L.	Provided by Spacelab. Changed category from regular to Spacelab.
76J Flowmeter, Gas	In	Reg.	Changed name from Flowmeter, Gas to Flowmeters to include both gas and liquid types.
93A Gas, Supplies	In	Reg.	
118I Manifold, Vacuum	In	Reg.	
187A Waste Storage Device	In	S. L.	Provided for by Spacelab. Changed category from regular to Spacelab.
- Power Cond. Eq.	In	S. L.	E.I. number 142B assigned. Provided by Spacelab. Changed category from regular to S. L.
- Gas Cond. Eq.	Out	Reg.	Part of Plumbing (EI 141A, EU 3).

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory***	Comment
- Water Cond. & Distr. Eq.	Out	Reg.	Part of Plumbing (EI 141A, EU 3)
- Crew Work Station	In	S.L.	E.I. number 55C assigned. Provided by Spacelab. Changed category from regular to S.L.
<u>Contractor Added E.I.s**</u>			
6A Airflow Work Sur- face	In	Reg.	To provide for pneumatic hold-down for small items in 0-g.
51F Coolant Loop, Liquid	In	Reg.	To provide liquid coolant for those E.I.s which require cold plating.
70C Equipment Restraint Device	In	Reg.	To provide a mechanical hold-down for small items in 0-g.
114G Liquid Storage & Dispensing Sys.	In	Reg.	General purpose storage and dispensing system for water and other fluids to be used to support research protocols.
141A Plumbing -	In	Reg.	General purpose lines, valves, fittings, etc., required to provide the interface in between E.I.s and between E.I.s and the Spacelab.
178B Thermocouple Indicator	In	Reg.	For general purpose thermocouple measurements, portable indicator.
<u>EU #4 - PREPARATION &amp; PRESERVATION UNIT</u>			
<u>Original NASA E.I.s*</u>			
14 Anesthetizer, Invertebrate	Out	Reg.	Moved to Invertebrate Holding Unit, E.U. 70.
18 Glove Box	In	Reg.	Changed number to 96 to place in alphabetical order.
18A Glove Box Liners	In	Reg.	Changed number to 96C to place in alphabetical order.
41 Centrifuge, Refrig. Hi Speed, 10 ml Tube	Out	Reg.	Replaced by Centrifuge, Blood Sample Processor (from Skylab)(EI 40A, EU 4)

\* Original E. I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
44	Chemicals	In	Reg.	
44A	Chemicals, Radio- active	In	Reg.	Name changed to chemicals, radioisotope tracers
48	Cleaner, Vacuum	Out	Reg.	Moved to maintenance repairs and fabrication unit, EU 6
77B	Freezer, Cryogenic	In	Reg.	
81	Freezer, Low Temp. (Holding)	In	Reg.	
83	Frig.	In	Reg.	
105	Kit, Bench Chemical Anal.	In	Reg.	Name changed to Kit, Chemical.
106	Kit, Hematology	In	Reg.	Name changed to Kit, Hematology & Urology.
108	Kit, Histology	In	Reg.	
110	Kit, Microbiology	In	Reg.	
114A	Kit, Microdissection	In	Reg.	Name changed to Kit, Dissection.
121	Mass Meas. Device (Macro)	In	Reg.	
122	Mass Meas. Device	In	Reg.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory**	Comment
126A	Microscope, Dissecting	In	Reg.	
159	Staining Sys.	In	Reg.	
179	Temperature Block	In	Int.	
186	Volumetric Meas. (Liquid) Kit	Out	Reg.	Function provided by Kit, Chemical(EI 105, EU 4).
70	Electrophoresis, Apparatus	In	P.I.	
118	Lyophilizer	In	P.I.	Category changed from Int. to P.I. UCSD scientists did not foresee a strong need for this E.I. It is also heavy and a major user of electrical power.
128	Millipore Filter	Out	Reg.	Included in Kit, Microbiology (EI 110, EU 4) & Kit, Hematology and Urology (EI 106, EU 4).
<u>Contractor Added E.I.s**</u>				
40A	Centrifuge, Blood Sample Processor	In	Reg.	Developed for Skylab.
80	Freezer, Genl.	In	Reg.	For storage of specimens at -20°C.
103B	Incubator	In	Int.	Small incubator for use on Mini labs and possibly in some Dedicated labs.
188	Work & Surgery Bench	In	Reg.	Moved from Biochemical & Biophysical Analysis Unit (EU 5).

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory	*** Comment
<u>EU #5 - BIOCHEMICAL AND BIOPHYSICAL ANALYSIS UNIT</u>				
<u>Original NASA E.I.s*</u>				
6	Air Particle Sample Collector	In	Reg.	Name changed to Air Particle Sampler
7	GEMSAEC	In	Reg.	Name changed to Autoanalyzer (GEMSAEC).
13	Ion Specific Analyzer	Out	Reg.	Function provided by Automated Potentiometric Electrolyte Analyzer (EI 7A, EU 5).
15A	Atmospheric Sampling Mnfld	In	Reg.	Name changed to Atmospheric Sampling System.
50A	Commutator, Gas Manifold	Out	Reg.	Included in Atmospheric Sampling System (EI 15A, EU 5)
85	Gas Analyzer, Auto Pysiological	Out	Reg.	Provided by Autoanalyzer (GEMSAEC) (EI 7, EU 5) and Automated Potentiometric Electrolyte Analyzer (EI 7A, EU 5).
91	Gas Analyzer, Mass Spec.	In	Reg.	
125B	Meters, Asst.	Out	Reg.	Provided by various other E.I.s or experiment-specific meters; e.g., Multimeter (EI 185, EU 6), Oscilloscope (EI 132, EU 2), Numeric Display (EI 63C, EU 2) Spacelab CDMS, etc.
-	Mass Measure- ment Device	Out	Reg.	Provided by Mass Measurement Device (Micro) (EI 122, EU 4).

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

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\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
125C	Meter, AOTS	Out	Reg.	Included in Kit, Hematology & Urology (EI 106, EU 4) (Refractometer).
138	pH Meter	In	Reg.	
157	Sound Level Meter	In	Int.	Category changed from Reg. to Intermittant as a result of UCSD consultant review.
-	Work Surgical Bench	Out	Reg.	E.I. number 188 assigned. E.I. was moved to Preparation and Preservation Unit (EU 4).
11	Analyzer, Genl. Spectropho.	In	Int.	
16B	Audiometer	Out	P.I.	Moved to Biomedical & Behavioral Research Support Unit (EU 12).
53	Counter, Colony (Auto)	Out	P.I.	This item will require substantial research and development which is not felt to be warranted by the need for it in the laboratory. UCSD scientists did not know of any commercially available models and felt that the manual colony counter (EI 54, EU 5) would fulfill laboratory requirements.
54	Counter, Colony (Manual)	In	Int.	
76L	Fibrometer, Blood Clot	In	P.I.	
93	Gas Analyzer, RH	In	Reg.	
179A	Thermocouples	In	P.I.	
-	Portable Ther- mometer + 3 Probes	In	Reg.	E.I. number 179D assigned. Name changed to Thermometer, Electronic.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory***	Comment
<u>Contractor Added E.I.s**</u>			
7A Automated Potentio- metric Electrolyte Analyzer	In	Reg.	For blood and urine electrolyte and gas measurements.
87 Gas Analyzer, Infrared	In	Int.	For general-purpose gas analysis.
<u>EU #6 - MAINTENANCE, REPAIR &amp; FABR. UNIT</u> <u>Original NASA EIs*</u>			
16E Bags, Plastic	Out	Reg.	Included in various kits (e.g., Kit, Cleanup (EI 106A, EU 6)) and also provided by Spacelab.
- "Handwipes", Betadyne	In	Reg.	E.I. number 97C assigned.
50B Compactor (Solids)	In	Reg.	
106A Kit, Cleanup	In	Reg.	
109 Kit, Linear Meas.	In	Reg.	
110B Kit, Organism Holding	Out	Reg.	Included in Kit, Vertebrate Management (EI 114B, EU 42) and Kit, Plant Management (EI 110D, EU 51)
113 Kit, Genl. Tool	In	S.L.	Provided by Spacelab. Category changed from regular to S.L.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
165	Sterilizer, Tool	In	Reg.	Provided by Spacelab. Category changed from regular to S.L.
162	Sterilizer, Autoclav (steam)	In	Reg.	
181G	Trash Can	In	S.L.	
185	Multimeter	In	Reg.	
69A	Electrometer	In	P.I.	
153B	Sensors, Asst.	In	P.I.	Category changed from Int. to P.I. UCSD Scientists did not see a general need for this meter.
<u>Contractor Added E.I.**</u>				
48	Cleaner, Vacuum	In	Reg.	Moved from Preparation & Preservation Unit (EU 4).
<u>EU #7 - ANCILLARY STORAGE UNIT</u> - <u>Original NASA E.I.s*</u>				
45	Chemical Storage Cabinet	In	Reg.	
167B	Storage, Genl.	In	S.L.	Provided by Spacelab. Category changed from regular to S.L.
167C	Storage, Film	In	S.L.	Provided by Spacelab. Category changed from regular to S.L.
<u>EU #11 - EVA CAPABILITY UNIT</u> <u>Original NASA E.I.s</u>				
3B	Airlock	In	SL	Provided by Spacelab as an option. Category changed from P.I. to S.L.
172	Spacesuit	In	P.I.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

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\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory***	Comment
- Test Console for Suit Preparation	In	P.I.	E.I. number 158C assigned. Name changed to Spacesuit Test Console.
<u>EU #23 - INTERNAL CENTRIFUGE UNITS</u> <u>Original NASA E.I.*</u>  43A Life Sciences Shuttle Research Centrifuge	In	Int.	Name changed to Centrifuge, Bioresearch
<u>EU #26 - RADIOBIOLOGY SUPPORT UNIT</u> <u>Original NASA E.I.s*</u>  16D Badges, Radiation  144C Radiation De- tector, Dosimeter  145 Radiation Detector, Genl.  149G Radiation Source Prepackaged & Shielded  147 Radiation Counter, Biochemical Sample	In  In  Out  In  In	P.I.  Int.  Int.  P.I.  Int.	Category changed from regular to P.I. These badges are for use with the Radiation Source, Shielded (EI 149G, EU 26) which is in the P.I. category.  Part of Radiation Counter, Biochemical Sample (EI 147, EU 26)  Name changed to Radiation Source, Shielded.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

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\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory**	Comment
<u>EU #12 - BIOMEDICAL/ BEHAVIORAL RESEARCH SUPPORT UNIT</u>			
<u>Original NASA E.I.s*</u>			
51D Control Console, Experimenter	In	P.I.	
65B Electrophysiology Backpack	In	Int.	
65C Electrophysiology Receiver	In	Int.	
144B Psychogalvanom- eter, GSR	In	P.I.	
153A Rotating Litter Chair	In	Int.	Changed category from P.I. to Intermittent. Changed name to Rotating Litter Chair and Console.
18D Custom Biteboards	In	P.I.	
131E Non-Visual Direction Indicator	In	P.I.	
133 Otolith Test Goggles	In	P.I.	
<u>Contractor Added E.I.**</u>			
16B Audiometer	In	P.I.	Moved from Biochemical & Biophysical Analysis Unit (EU 5)

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

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\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory	Comment
<u>EU #31 - BIOMEDICAL RE- SEARCH SUPPORT UNIT</u>				
<u>Original NASA E.I.s*</u>				
18C	Exercise Physio- logical Equipment	In	Reg.	Name changed to Exercise Equipment, Physiological. Number changed to E.I. 70C to place into alphabetical order.
76K	Flowmeter, Doppler	Out	Reg.	Included in Kit, Human Physiology (EI 110C, EU 31).
110C	Kit, Physiology	In	Reg.	Name changed to Kit, Human Physiology.
125D	Metabolic Analyzer	Out	Reg.	Provided by Cardiopulmonary Analyzer (EI 38F, EU 31).
139	Plethysmograph, Limb	In	Int.	
181B	Transducer, Plethysmograph	Out	Int.	Part of Plethysmograph, Limb (EI 139, EU 31).
182J	Coupler, Vectorcardiogram	In	Reg.	
-	Sonocardiogram	In	Int.	E.I. number 156F assigned.
117	LBNP	In	Int.	
-	Medical, Physical Examining Kit	Out	Reg.	Items are included in Kit, Human Physiology (EI 110C, EU 31).

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
16F	Coupler, Ballisto- cardiogram	In	P.I.	Name changed to Ballistocardiogram Coupler
140	Coupler, Phono/ Vibracardiogram	In	P.I.	Name changed to Phonovibracardiogram Coupler
19D	Body Mass Meas- urement Device	In	Reg.	
<u>Contractor Added E.I.s**</u>				
38F	Cardiopulmonary Analyzer	In	Reg.	Takes the place of the Metabolic Analyzer (EI 125D, EU 31).
182E	Urine Volume Meas Syst.	In	Reg.	To measure human (female & male) urine void volume.
<u>EU #40 - Small Vertebrate Holding Unit</u>				
30A	Cage, Rat/ Hamster, Standard	In	Reg.	
76F	Flowmeter, H <sub>2</sub> O	Out	Reg.	Part of Holding Unit, Small Vertebrate (EI 103, EU 40).
76H	Flowmeter, Coupler	Out	Reg.	Part of Holding Unit, Small Vertebrate (EI 103, EU 40).
103	Holding Unit, Small Vertebrate	In	Reg.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory**	Comment
118D	Manifold, Or- ganism Water	Out	Reg.	Part of Holding Unit, Small Vertebrate (EI 103, EU 40).
174	Tank, Vertebrate Water	Out	Reg.	Moved to Vertebrate Research Support Unit (EU 42).
28	Cage, Total Metabolic, Rats	In	Int.	Changed name to Cage, Metabolic, Rats.
<u>Contractor Added E.I.s **</u>				
131J	Orb. Frog Otolith Exper. Package	In	P.I.	Scientific experiment package to be flown in early life sciences payloads.
99	Holding Unit, Common	In	Reg.	It defines that part of the holding units which are common to the various experiment organisms
<u>EU #41 - PRIMATE HOLD- ING UNIT</u>				
<u>Original NASA E.I.s*</u>				
28A	Cage, Monkey	In	Reg.	Number changed to 101C. Name changed to Holding Unit, Primate.
100	Holding Unit, Metabolism, Primate	Out	Int.	Replaced by Holding Unit, Monkey Pod (EI 101B, EU 41).
156E	Signal Conditioning Rack	Out	P.I.	Interface equipment specific to laboratory configuration.
<u>Contractor Added E.I.**</u>				
101B	Holding Unit, Monkey Pod	In	Int.	Replaces Holding Unit, Metabolism, Primate (EI 100, EU 41).

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory	Comment
<u>EU #42 - Vertebrate Research</u>			
<u>Support Unit</u>			
<u>Original NASA E.I.s*</u>			
115 Kit, Veterinary	Out	Reg.	Functions provided by Kit, Vertebrate Physiology (EI 114C, EU 42) and
			Kit, Dissection (EI 114A, EU4).
150B Receiver	In	Reg.	
76G "Physiological Multichannel Sensor System"	In	P.I.	E.I. number changed from 76G to 138E in order to place into alphabetical order.
143E Pressure Cuff	Out	P.I.	Part of Kit, Vertebrate Physiology (EI 114C, EU 42).
143F Pressure Cuff Pump	Out	P.I.	Part of Kit, Vertebrate Physiology (EI 114C, EU 42).
155A Sensor, Implanted	Out	P.I.	Part of Kit, Vertebrate Physiology (EI 114C, EU 42).
177 Temp. Sensor, Body	Out	Int.	Part of Kit, Vertebrate Physiology (EI 114C, EU 42).
181C Transducer, Blood Pressure	Out	P.I.	Part of Kit, Vertebrate Physiology (EI 114C, EU 42).
<u>Contractor Added E.I.s**</u>			
114B Kit, Vertebrate Management	In	Reg.	Includes various tools, restraints, and other equipment for managing vertebrates in the spacecraft environment.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory	*** Comment
114 C	Kit, Vertebrate Physiology	In	Reg.	Includes various equipment for making physiological measurements on vertebrates.
174	Tank, Vertebrate, Water	In	Reg.	Moved from E.U. 40, Small Vertebrate Holding Unit (supports both small vertebrates and primates).
182P	Ventilation Unit, Vertebrate	In	Reg.	An open loop type ECS for ventilation of the Holding Unit, Small Vertebrate (EI 103, EU 40), or the Primate (EI 101C, EU 41).
182R	Vertebrate ECS	In	Reg.	A closed loop type of ECS for support of the Holding Unit, Small Vertebrate (EI 103, EU 40) or the Holding Unit, Primate (EI 101C, EU 41).
<u>EU #50 - PLANT HOLDING UNIT</u>				
<u>Original NASA E.I.s*</u> 26B Cage, Metabolic Plant		In	Int.	
29	Cage, Plant	In	Reg.	
101	Holding Unit, Plants	In	Reg.	
175	Tank, Plant/ Invertebrate	In	Reg.	Name changed from Tank, Plant/Invert to Tank, Plant/Invert. Water
<u>EU #51 - PLANT RESEARCH SUPPORT UNIT</u>				
<u>Original NASA E.I.s*</u>				
50	Clinostat	In	Int.	Name changed to Clinostat for Plants
111	Kit, Plant Tool	In	Reg.	Name changed to Kit, Plant Management.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number		Dispo- sition	Cate- gory***	Comment
30B	Cage Shelf, Plant Seedlings	Out	Reg.	Part of Holding Unit, Plant (EI 101, EU 50)
131D	Motorized Plant Growth Monitor	In	P.I.	
143C	Pump, Gas Circulating	Out	Reg.	
156B	Squibs, Fixative	Out	Int.	
156C	Squib, Firing Apparatus	Out	Int.	
<u>EU #60 - CELLS AND TIS- SUES HOLDING UNIT</u>				
<u>Original NASA E.I.s*</u>				
25B	Colony Chamber, Sealable	In	Reg.	Name changed to Holding Unit, Cells/Tissues
98A	Holding Unit Incubator, C/T	In	Reg.	
26A	Cage, MMB, C/T	In	Reg.	
-	Fluid Handling Kit	Out	Reg.	Provided by Kit, Chemical (EI 105, EU 4)

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

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\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory**	Comment
<u>Contractor Added E.I.**</u>			
187C Woodlawn Wanderer	In	Int.	Self-contained, autonomous holding unit to determine the zero-g effect on human cells.
<u>EU #61 - CELLS &amp; TISSUES RESEARCH SUPPORT UNIT</u> <u>Original NASA E.I.s*</u>			
124 Media, Prepared	In	Reg.	
50 Clinostat	In	Reg.	Number changed to E.I. 50A. Name changed to Clinostat for Cells and Tissues.
<u>EU #70 - INVERTEBRATE HOLDING UNIT</u> <u>Original NASA E.I.s*</u>			
98C Holding Unit, Incubator - Invertebrates	In	Reg.	Name changed to Holding Unit, Invertebrates
113A Kit, Tool - Insect Manipulator	In	Reg.	Name changed to Kit, Invertebrate Management (ET 113A, EU 61).
25 Cage, Inverte- brates	In	Reg.	
<u>Contractor Added E.I.**</u>			
14 Anesthetizer, Invert.	In	Reg.	E.I. moved from Preparation and Preservation Unit, EU #4, to Invertebrate Holding Unit, EU #70.

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory**	Comment
<u>EU #80 - LIFE SUPPORT</u> <u>SUBSYSTEM TEST UNIT</u> <u>Original NASA E.I.s*</u>			
115F      LSS Test Console	In	Int.	
142      Portable LSS	In	P.I.	
<u>EU #91 - MSI MEASURE-</u> <u>MENT UNIT</u> <u>Original NASA E.I.s*</u>			
144      Psychomotor Per- formance Console	In	Int.	
15D      Audio Stereo Headset	In	P.I.	
119      MSI Task Simulator	In	P.I.	
131H      Optiscan-Field & Fixed	In	P.I.	
176H      Taskboard, Force/Torque	In	P.I.	
182K      Vision Tester	In	P.I.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

E.I./EU Name & Number	Dispo- sition	Cate- gory	*** Comment
<u>EU #93 - Mobility Unit</u>			
<u>Original NASA E.I.s*</u>			
15      Anthropometric Grid	In	Int.	
126I    Mobility Unit, Protective Corridor	In	Int.	
122A    Mass, Test Variable Size	In	P.I.	

\* Original E.I. name and number presented by NASA to the contractor at the beginning of study.

\*\* Added E.I.s are those added by the contractor as a result of the study.

\*\*\* Category assigned by the contractor as a result of studying E.I. requirements and Spacelab provided equipment. If it is different from original NASA category it is explained under comments.

**SECTION 2**

**PRELIMINARY EQUIPMENT ITEM SPECIFICATION DATA**

## SECTION 2

### PRELIMINARY EQUIPMENT ITEM SPECIFICATION DATA

All equipment items (E.I.s) in the final Common Equipment Inventory are listed in Table 2-1 and 2-2. Those in Table 2-1 have been categorized as Regular or Intermittent E.I.s (see Section 1) and have been defined in the individual specification sheets that make up the major part of this volume. Thus, Table 2-1 is a table of contents of the specification sheets which are included herein in numerical order.

E.I.s which have been categorized as Spacelab (S.L.) or Principal Investigator (P.I.) are listed in Table 2-2, and have not been defined in specification sheets. These will be provided by the Spacelab as "mission dependent equipment", or by the P.I. as experiment specific equipment. Their development & specification is not the responsibility of the Life Sciences Laboratory contractor.

The E.I.s in Tables 2-1 and 2-2 are cross-referenced to the equipment units (E.U.s) in which they belong. As an aid to the reader, an additional table (2-3) is provided which lists all the E.I.s, independent of category, but according to the E.U.s to which they have been assigned. Table 2-4 contains the definition of the most used abbreviations, symbols, and terms used in the specification sheets.

Following Table 2-4 are the specification sheets. Each is written according to a standard format which includes the following headings in the order listed below.

1. Equipment Item Number and Name

Most E.I. numbers and names correspond to those developed during the preceding Life Sciences Payload Definition & Integration Studies (Life Sciences Payload Definition and Integration Study, Report No. GDC-DBD72-002, Contract NAS8-26468, General Dynamics, Convair Aerospace Division, San Diego, CA, March 1972). Changes in name or number, or added E.I.s were presented earlier in the disposition worksheets of Section 1. In cases where E.I.s were added, E.I. numbers were assigned based upon the original equipment inventory so that no duplication of E.I. numbers resulted.

2. Equipment Unit Number and Name

The E.U. to which the E.I. was assigned.

3. Purpose

The general reason why each E.I. is needed in the life sciences laboratories is stated under this heading.

#### 4. Requirements

The known requirements of each E.I. are stated under this heading. Requirements pertaining to life sciences research are addressed rather than general requirements for space flight application. The latter tend to be common for all E.I.s and include such criteria as minimum weight, minimum power consumption, safety considerations, null gravity performance, etc.

#### 5. Hardware Status

Under this heading, a "Rating" is first listed according to the following definitions:

- SRT - Item requiring preliminary basic research to prove feasibility or advanced technology.
- New Development - No applicable commercial or space hardware presently available. Special design or material will be required.
- Redesign - Commercial hardware exists but would require a major redesign for use in space. Or, the E.I. will require fabrication using available material and standard design techniques.
- Modification - Commercial hardware exists and its design could be used with minor modifications if the equipment was reconstructed using space-rated materials and parts.
- Repackage - Applicable commercial or space hardware or hardware designs exist. However, due to spacecraft constraints, they would require repackaging and/or slight modification.
- Space-Qualified - Hardware or hardware designs are available which could be used essentially as is.

Following the rating, specific comments regarding the hardware status of each E.I. are given.

#### 6. Technical Description

Estimates of weight, power, and volume for flight-type equipment are included under this heading as well as any other descriptive technical data of significance.

7. Development Time

Under this heading, the estimated development time of each E.I. is given. These times are either: (1) the duration from the start of development of the E.I. to flight hardware completion, but excluding flight simulation testing, or (2) in the case of E.I.s currently undergoing development, the time from the publication date of this report to estimated flight hardware completion.

8. References

Where applicable references are known, they are listed under this heading.

9. In addition to the information contained under the headings listed above, additional information is often included for the E.I.s in the form of catalog sheets, pictures, specification sheets, etc., taken from miscellaneous sources.

TABLE 2-1

## REGULAR &amp; INTERMITTENT CATEGORY E.I.

Table of contents of specification sheets contained in this volume.

E.I. No.	Name	Unit Properties for 7-Day Ded. Lab.		
		Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
1	ACCELEROMETER	0.1	0	0.03
1A	ACCELEROMETER COUPLER	0.05	1	0.01
6	AIR PARTICLE SAMPLER	2.7	50	0.85
6A	AIRFLOW WORK SURFACE	5	75	6
7	AUTOANALYZER (GEMSAEC)	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	12.7	100	57
11	ANALYZER, GENL. SPECTROPHOT.	30	240	90
14	ANESTHETIZER, INVERT.	0.2	0	1
14B	ANTENNAS, ASSORTED	0.1	0	0.03
15	ANTHROPOMETRIC GRID	1.8	0	2.8
15A	ATMOS. SAMPLING SYSTEM	10	20	28
19D	BODY MASS MEAS. DEVICE	36.5	15	675
25	CAGE, INVERTEBRATES	0.3	0	0.2
25B	COLONY CHAMBER, SEALABLE	0.2	0	0.1
26A	CAGE, METABOLIC, C/T	0.8	5	0.9
26B	CAGE, METABOLIC, PLANT	7	30	74.6
28	CAGE, METABOLIC, RATS	8	20	28.5
29	CAGE, PLANT	4.5	0	56.6
30A	CAGE, RAT, HAMSTER, STANDARD	2.3	9	11
31	CALCULATOR, POCKET	0.47	0	0.4
32	CAMERA, CINE	5	13	5
32A	CAMERA CONTROLLER	13.6	100	28.3
33	CAMERA, POLAROID	3.3	0	5.6
36	CAMERA, 35 MM AND STROBE	2	0	2
37	CAMERA, VIDEO, B/W	4.4	15	3
38	CAMERA, VIDEO, COLOR	7.7	69	6.2
38B	CAMERA MOUNTS	3	0	3
38D	CAMERA TIMER, VIDEO	4	10	3
38F	CARDIOPULMONARY ANALYZER	90.7	200	172
40A	CENTRIFUGE, BLD SMPL PROCESSOR	12.7	100	25
43A	CENTRIFUGE, BIORESEARCH	250	354	6800
44	CHEMICALS	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	4.0	0	14.1
48	CLEANER, VACUUM	2.3	100	10
50	CLINOSTAT (FOR PLANTS)	3	10	20
50A	CLINOSTAT (FOR C/T)	2	10	4
50B	COMPACTOR, SOLIDS	18	100	113
51F	COOLANT LOOP, LIQUID	30	50	25
54	COUNTER, COLONY, MANUAL	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	13.6	60	42.5
63C	DISPLAY, NUMERIC	2	2	4
64	EEG COUPLER	0.2	2	0.5
65	EEG COUPLER	0.2	2	0.5

TABLE 2-1 (Cont'd)

E.I. No.	Name	Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
65B	ELECTROPHYS. BACKPACK	0.3	0	0.23
65C	ELECTROPHYS. RECEIVER	2.7	25	5.0
66	EMG COUPLER	0.2	2	0.5
70C	EQUIPMENT RESTRAINT DEVICE	0.5	0	1
70E	EXERCISE EQUIP., PHYSIOL.	96	18	992
75C	FILM, CINE	0.54	0	0.54
75F	FILM, POLAROID	0.16	0	0.13
76C	FILM, 35 MM	0.13	0	0.05
76J	FLOWMETERS	0.5	1	0.5
77B	FREEZER, CRYOGENIC	21.6	10	74.1
80	FREEZER, GENERAL	15	200	61.4
81	FREEZER, LOW TEMP.	8	10	30.5
83	FRIG. (REFRIGERATOR)	18	50	120
87	GAS ANALYZER, INFRARED	11.3	50	42.6
91	GAS ANALYZER, MASS SPEC.	25	50	20
93	GAS ANALYZER, RH	5.2	6	13
93A	GAS SUPPLIES	5.75	0	18
96	GLOVE BOX, PORTABLE	4.5	0	25
96C	GLOVE BOX LINERS	0.5	0	1
97C	HANDWIPES, BETADYNE	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	23	30	188
98C	HOLD. UNIT, INVERTEBRATES	23	50	188
99	HOLDING UNIT, COMMON	20.4	50	188
101	HOLDING UNIT, PLANT	25	500	188
101B	HOLDING UNIT, MONKEY POD	53	100	425
101C	HOLDING UNIT, PRIMATE	113	100	340
103	HOLDING UNIT, SM. VERT.	13.6	0	188
103B	INCUBATOR	5	5	8
105	KIT, CHEMICAL	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	5	0	9
106A	KIT, CLEANUP	1.5	0	4
108	KIT, HISTOLOGY	1	0	1
109	KIT, LINEAR MEAS.	1	0	1
110	KIT, MICROBIOLOGY	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	3	0	8
111	KIT, PLANT MANAGEMENT	1	0	1
113A	KIT, INVERT. MANAGEMENT	1	0	2
114A	KIT, DISSECTION	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	13	0	18
115F	LSS TEST CONSOLE	15	0	560
116	LOG BOOKS	0.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	78.7	26	2373
1181	MANIFOLD, VACUUM	9.1	0	28.3
121	MASS MEAS. DEVICE, MACRO	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	12	15	25
124	MEDIA, PREPARED	0.45	0	0.5
126	MICROSCOPE, COMPOUND	11	15	27.4
126A	MICROSCOPE, DISSECTING	9	100	28
1261	MOBILITY UNIT, PROT. CORRIDOR	22.7	0	56.6

TABLE 2-1 (Cont'd)

E.I. No.	Name	Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
126J	MICK. ACCESS. KIT, COMPND	10	15	25
132	OSCILLOSCOPE AND CAMERA	11.7	75	28.9
134B	PAPER, RECORDING	0.5	0	1.2
138	PH METER	1.8	20	5.2
138B	PHOTOCELL COUPLER	0.2	2	0.5
139	PLETHYSMOGRAPH, LIMB	2.4	5	6
141A	PLUMBING	20	2	15
143G	PRESSURE COUPLER	0.2	2	0.5
144	PSYCHOMOTOR PERFORM. CONSOLE	8.2	15	10.3
144C	RADIATION DETECTOR, DOSIM.	0.3	0	0.5
147	RADIATION COUNTER	15	50	20
150A	RECORDER, STRIP CHART	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	0.5	10	1
153	RECORDER, VOICE	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	100.2	127	239
156	SIGNAL CONDITIONERS (COUPLERS)	0.2	2	0.5
156F	SONOCARDIOGRAM	19	32	59
157	SOUND LEVEL METER	13.6	0	33.4
159	STAINING SYSTEM	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	11	300	34.7
165	STERILIZER, TOOL	1	110	1
174	TANK, VERTEBRATE WATER	8.5	5	28.3
175	TANK, PLANT/INVERT. WATER	1.7	0	3
178B	THERMOCOUPLE INDICATOR	6	8	9.4
179	TEMPERATURE BLOCK	4.5	200	1.7
179D	THERMOMETER, ELECTRONIC	5.4	14	8.7
180	TIMER, EVENT	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	0.2	1	0.4
182E	URINE VOLUME MEAS. SYST.	SHUTTLE		
182J	VCG COUPLER	0.2	2	0.5
182P	VENTILATION UNIT, VERT.	19	40	32.7
182K	VERTEBRATE ECS	38	320	121
185	MULTIMETER	2	0	2.4
187C	WOODLAWN WANDERER	10	15	12.9
188	WORK AND SURGICAL BENCH	136	1000	420

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TABLE 2-2

## SPACELAB &amp; PRINCIPAL INVESTIGATOR CATEGORY E.I.

(Not included in Specification Sheets)

SPACELAB (S.L.) CATEGORY E.I.'S

3B AIRLOCK	SHUTTLE
51 COMPUTER, DIGITAL	SPACELAB
55A CREW MOBILITY AIDS	SPACELAB
55B CREW RESTRAINTS	SPACELAB
55C CREW WORK STATION	SPACELAB
56A DATA MGMT SYST BUSES	SPACELAB
58A DMS CONTROL AND DISPLAY STA.	SPACELAB
58B DMS REMOTE ACQUISITION UNIT	SPACELAB
113 KIT, GENERAL TOOL	SPACELAB
126G MONITOR, VIDEO	SPACELAB
142B POWER COND. EQUIP.	SPACELAB
167B STORAGE, GENERAL	SPACELAB
167C STORAGE, FILM	SPACELAB
176 TAPE, VIDEO	SPACELAB
181G TRASH CAN	SPACELAB
182T VIDEO TAPE RECORDER	SPACELAB
187A WASTE STORAGE DEVICE	SPACELAB

PRINCIPAL INVESTIGATOR (P.I.) CATEGORY E.I.'S

	Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
15D AUDIO STEREO HEADSET	0.7	0	5.7
16B AUDIOMETER	4.5	25	4.3
16D BADGES, RADIATION	0.2	0	0.1
16F BALLISTOCARDIOGRAM COUPLER	0.1	1	1
18D CUSTOM RITE BOARDS	0.23	0	0.03
51D CONTROL CONSOLE, EXPERIMENTER	22.7	100	113.3
69A ELECTROMETER	3.7	3	7.3
70 ELECTROPHORESIS APPARATUS	9.1	85	25.5
76L FIBROMETER, BLOOD CLOT	4.5	40	19.8
118 LYOPHILIZER	23	300	143
119 MSI TASK SIMULATOR	22.7	5	200
122A MASS, TEST, VARIABLE SIZE	0	0	0
131D MOTORIZED PLANT GROWTH MONITOR	0.5	5	0.6
131E NON-VISUAL DIRECTION INDICATOR	4.1	0	2.8
131H OPTISCAN - FIELD AND FIXED	2.3	5	8.5
131J ORB. FROG OTOL. EXPER. PACKAGE	45	20	80
133 OTOLITH TEST GOGGLES	0.2	0	2.8
138L PHYSIOL. MULTICHAN. SENS SYS.	0.2	0	1.4
140 PHONOVIBRACARDIOGRAM COUPLER	0.2	1	0.3
142 PORTABLE LSS	30.4	0	79
144B PSYCHOALVANOMETER, GSK	0.5	1	0.3
149G RAD. SOURCE, SHIELDED	65	5	28.3
153B SENSORS, ASSORTED	0.5	0	0.3
158C SPACESUIT TEST CONSOLE	35	50	50
172 SPACESUIT	36.3	1	198.2
176H TASKBOARD, FORCE/TORQUE	22.7	5	56.5
179A THERMOCOUPLES	0.5	0	0.3
182K VISION TESTER	22.7	100	113.3

TABLE 2-3

## TOTAL EQUIPMENT INVENTORY LISTED BY EQUIPMENT UNITS (E.U.)

	Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
<u>EU 1 VISUAL RECORDS + MICROSCOPY</u>			
32 CAMERA, CINE	5	13	5
32A CAMERA CONTROLLER	13.6	100	28.3
33 CAMERA, POLAROID	3.3	0	5.6
36 CAMERA, 35 MM AND STROBE	2	0	2
37 CAMERA, VIDEO, B/W	4.4	15	3
38 CAMERA, VIDEO, COLOR	7.7	69	6.2
38B CAMERA MOUNTS	3	0	3
38D CAMERA TIMER, VIDEO	4	10	3
75C FILM, CINE	0.54	0	0.54
75F FILM, POLAROID	0.16	0	0.13
76C FILM, 35 MM	0.13	0	0.05
114L LAMP, PORTABLE HI INT. PHOTO	6.3	150	6
116 LOG BOOKS	0.5	0	0.4
126 MICROSCOPE, COMPOUND	11	15	27.4
126J MICK. ACCESS. KIT, COMPND	10	15	25
134B PAPER, RECORDING	0.6	0	1.2
150A RECORDER, STRIP CHART	11.8	0	16.9
<u>EU 2 DATA MANAGEMENT</u>			
14B ANTENNAS, ASSORTED	0.1	0	0.03
31 CALCULATOR, POCKET	0.47	0	0.4
51 COMPUTER, DIGITAL	SPACELAB		
56A DATA MGMT SYST BUSES	SPACELAB		
58A DMS CONTROL AND DISPLAY STA.	SPACELAB		
58L DMS REMOTE ACQUISITION UNIT	SPACELAB		
63B DISPLAY KEYBOARD, PORTABLE	13.6	60	42.5
63C DISPLAY, NUMERIC	2	2	4
64 EEG COUPLER	0.2	2	0.5
65 EEG COUPLER	0.2	2	0.5
66 ENG COUPLER	0.2	2	0.5
126G MONITOR, VIDEO	SPACELAB		
132 OSCILLOSCOPE AND CAMERA	11.7	75	28.9
138F PHOTOCELL COUPLER	0.2	2	0.5
143G PRESSURE COUPLER	0.2	2	0.5
153 RECORDER, VOICE	1	0	1
156 SIGNAL CONDITIONERS (COUPLERS)	0.2	2	0.5
176 TAPE, VIDEO	SPACELAB		
180 TIMER, EVENT	0.2	0	0.2
181D TRANSDUCER, PRESSURE	0.2	1	0.4
182T VIDEO TAPE RECORDER	SPACELAB		
<u>EU 3 LIFE SCI. EXPER. SUPPORT UNIT</u>			
1 ACCELEROMETER	0.1	0	0.03
1A ACCELEROMETER COUPLER	0.05	1	0.01
6A AIRFLOW WORK SURFACE	5	75	6
51F COULANT LOOP, LIQUID	30	50	25
55A CREW MOBILITY AIDS	SPACELAB		
55B CREW RESTRAINTS	SPACELAB		

TABLE 2-3 (Cont'd)

	Wt., kg	Pwr., w	Vol., dm <sup>3</sup>
55C CREW WORK STATION	SPACELAB		
70C EQUIPMENT RESTRAINT DEVICE	0.5	0	1
76J FLOWMETERS	0.5	1	0.5
93A GAS SUPPLIES	5.75	0	18
114G LIQUID STOR. AND DISPENS. SYS.	13	0	18
118I MANIFOLD, VACUUM	9.1	0	28.5
141A PLUMBING	20	2	15
142B POWER COND. EQUIP.	SPACELAB		
178B THERMOCOUPLE INDICATOR	6	8	9.4
167A WASTE STORAGE DEVICE	SPACELAB		
<u>EU 4 PREPARATION + PRESERV. UNIT</u>			
40A CENTRIFUGE, BLD SMPL PROCESSOR	12.7	100	25
44 CHEMICALS	0.5	0	1.0
44A CHEMICALS, RADIOISOT. TRACERS	0.3	0	0.5
70 ELECTROPHORESIS APPARATUS	9.1	85	25.5
77B FREEZER, CRYOGENIC	21.6	10	74.1
80 FREEZER, GENERAL	15	200	61.4
81 FREEZER, LOW TEMP.	8	10	30.5
83 FRIG. (REFRIGERATOR)	18	50	120
96 GLOVE BOX, PORTABLE	4.5	0	25
96C GLOVE BOX LINERS	0.5	0	1
103B INCUBATOR	5	5	8
105 KIT, CHEMICAL	1.5	0	5
106 KIT, HEMATOLOGY AND UROLOGY	5	0	9
108 KIT, HISTOLOGY	1	0	1
110 KIT, MICROBIOLOGY	2	0	3
114A KIT, DISSECTION	1	0	2
118 LYOPHILIZER	23	300	143
121 MASS MEAS. DEVICE, MACRO	11.8	15	32.8
122 MASS MEAS. DEVICE, MICRO	12	15	25
126A MICROSCOPE, DISSECTING	9	100	28
159 STAINING SYSTEM	2.2	0	3.5
179 TEMPERATURE BLOCK	4.5	200	1.7
188 WORK AND SURGICAL BENCH	136	1000	420
<u>EU 5 BIOCHEM. + BIOPHYS. ANAL. UNIT</u>			
6 AIR PARTICLE SAMPLER	2.7	50	0.85
7 AUTOANALYZER (GEMSAEC)	26	200	40
7A AUTO POTENTIO. ELEC. ANAL.	12.7	100	57
11 ANALYZER, GENL. SPECTROPHOT.	30	240	90
15A ATMOS. SAMPLING SYSTEM	10	20	28
54 COUNTER, COLONY, MANUAL	1.5	50	1.5
76L FIBROMETER, BLOOD CLOT	4.5	40	19.8
87 GAS ANALYZER, INFRARED	11.3	50	42.6
91 GAS ANALYZER, MASS SPEC.	25	50	20
93 GAS ANALYZER, RH	5.2	6	13
138 PH METER	1.8	20	5.2
157 SOUND LEVEL METER	13.6	0	33.4
179A THERMOCOUPLES	0.5	0	0.3
179D THERMOMETER, ELECTRONIC	5.4	14	8.7

TABLE 2-3 (Cont'd)

	Wt, kg	Pwr, w	Vol., dm <sup>3</sup>
<u>EU 6 MAINT. REPAIR + FAB. UNIT</u>			
48 CLEANER, VACUUM	2.3	100	10
50B COMPACTOR, SOLIDS	18	100	113
69A ELECTROMETER	3.7	3	7.3
97C HANDWIPES, BETADYNE	0.3	0	0.3
106A KIT, CLEANUP	1.5	0	4
109 KIT, LINEAR MEAS.	1	0	1
113 KIT, GENERAL TOOL	SPACELAB		
153B SENSORS, ASSORTED	0.5	0	0.3
162 STERILIZER, AUTOCLAVE	11	300	34.7
165 STERILIZER, TOOL	1	110	1
181G TRASH CAN	SPACELAB		
185 MULTIMETER	2	0	2.4
<u>EU 7 AUXILIARY STORAGE UNIT</u>			
45 CHEMICAL STORAGE CABINET	4.0	0	14.1
167B STORAGE, GENERAL	SPACELAB		
167C STORAGE, FILM	SPACELAB		
<u>EU 11 EVA CAPABILITY UNIT</u>			
3B AIRLOCK	SHUTTLE		
158C SPACESUIT TEST CONSOLE	35	50	50
172 SPACESUIT	36.3	1	198.2
<u>EU 23 INTERNAL CENTRIFUGE UNIT</u>			
43A CENTRIFUGE, BIORESEARCH	250	354	6800
<u>EU 26 RADIOBIOLOGY SUPPORT UNIT</u>			
16D BADGES, RADIATION	0.2	0	0.1
144C RADIATION DETECTOR, DOSIM.	0.3	0	0.5
147 RADIATION COUNTER	15	50	20
149G RAD. SOURCE, SHIELDED	65	5	28.3
<u>EU 12 BIOMED/BEHAV. RES. SUP. UNIT</u>			
16B AUDIOMETER	4.5	25	4.3
18D CUSTOM BITE BOARDS	0.23	0	0.03
51D CONTROL CONSOLE, EXPERIMENTER	22.7	100	113.3
65B ELECTROPHYS. BACKPACK	0.3	0	0.23
65C ELECTROPHYS. RECEIVER	2.7	25	5.0
131E NON-VISUAL DIRECTION INDICATOR	4.1	0	2.8
133 OTOLITH TEST GOGGLES	0.2	0	2.8
144B PSYCHOALVANOMETER, GSR	0.5	1	0.3
153A ROTATING LITTER CHAIR/CONSOLE	100.2	127	239
<u>EU 31 BIOMEDICAL RESEARCH SUP. UNIT</u>			
16F BALLISTOCARDIOGRAM COUPLER	0.1	1	1
19D BODY MASS MEAS. DEVICE	36.5	15	675
38F CARDIOPULMONARY ANALYZER	90.7	200	172
70E EXERCISE EQUIP., PHYSIOL.	96	18	992
110C KIT, HUMAN PHYSIOLOGY	3	0	8
117 LOWER BODY NEG. PRESS. DEVICE	78.7	26	2373

TABLE 2-3 (Cont'd)

	Wt. kg	Pwr, w	Vol., dm <sup>3</sup>
139 PLETHYSMOGRAPH, LIMB	2.4	5	6
140 PHONOVIBRACARDIOGRAM COUPLER	0.2	1	0.3
156F SONOCARDIOGRAM	19	32	59
182E URINE VOLUME MEAS. SYST.	SHUTTLE		
182J VCG COUPLER	0.2	2	0.5
<u>EU 40 SMALL VERT. HOLDING UNIT</u>			
28 CAGE, METABOLIC, RATS	8	20	28.3
30A CAGE, RAT, HAMSTER, STANDARD	2.3	9	11
99 HOLDING UNIT, COMMON	20.4	50	188
103 HOLDING UNIT, SM. VERT.	13.6	0	188
131J ORB. FROG OTOL. EXPER. PACKAGE	45	20	80
<u>EU 41 PRIMATE HOLDING UNIT</u>			
101B HOLDING UNIT, MONKEY POD	53	100	425
101C HOLDING UNIT, PRIMATE	113	100	340
<u>EU 42 VERT. RESEARCH SUPPORT UNIT</u>			
114B KIT, VERTEBRATE MANAGEMENT	3	0	6
114C KIT, VERTEBRATE PHYSIOLOGY	3	0	6
138E PHYSIOL. MULTICHAN. SENS SYS.	0.2	0	1.4
150B RECEIVER, BIOTELEMETRY	0.5	10	1
174 TANK, VERTEBRATE WATER	8.5	5	28.3
182P VENTILATION UNIT, VERT.	19	40	32.7
182R VERTEBRATE ECS	38	320	121
<u>EU 50 PLANT HOLDING UNIT</u>			
26B CAGE, METABOLIC, PLANT	7	30	74.6
29 CAGE, PLANT	4.5	0	56.6
101 HOLDING UNIT, PLANT	25	500	188
175 TANK, PLANT/INVERT. WATER	1.7	0	3
<u>EU 51 PLANT RESEARCH SUPPORT UNIT</u>			
50 CLINOSTAT (FOR PLANTS)	3	10	20
111 KIT, PLANT MANAGEMENT	1	0	1
131D MOTORIZED PLANT GROWTH MONITOR	0.5	5	0.6
<u>EU 60 CELLS/TISSUES HOLDING UNIT</u>			
25B COLONY CHAMBER, SEALABLE	0.2	0	0.1
26A CAGE, METABOLIC, C/T	0.8	5	0.9
98A HOLDING UNIT, CELLS/TISSUES	23	30	188
187C WOODLAWN WANDERER	10	15	12.9
<u>EU 61 CELLS/TISSUES RES. SUP. UNIT</u>			
50A CLINOSTAT (FOR C/T)	2	10	4
124 MEDIA, PREPARED	0.45	0	0.5
<u>EU 70 INVERTEBRATE HOLDING UNIT</u>			
14 ANESTHETIZER, INVERT.	0.2	0	1
25 CAGE, INVERTEBRATES	0.3	0	0.2
98C HOLD. UNIT, INVERTEBRATES	23	50	188
113A KIT, INVERT. MANAGEMENT	1	0	2

TABLE 2-3 (Cont'd)

	<u>Wt., kg</u>	<u>Pwr., w</u>	<u>Vol., dm<sup>3</sup></u>
<u>EU 80 LSS TEST UNIT</u>			
115F LSS TEST CONSOLE	15	0	560
142 PORTABLE LSS	30.4	0	79
<u>EU 91 MSI MEASUREMENTS UNIT</u>			
15D AUDIO STEREO HEADSET	0.7	0	5.7
119 MSI TASK SIMULATOR	22.7	5	200
131H OPTISCAN - FIELD AND FIXED	2.3	5	8.5
144 PSYCHOMOTOR PERFORM. CONSOLE	8.2	15	10.3
176H TASKBOARD, FORCE/TORQUE	22.7	5	56.6
182K VISION TESTER	22.7	100	113.3
<u>EU 93 MOBILITY UNIT</u>			
15 ANTHROPOMETRIC GRID	1.8	0	2.8
122A MASS, TEST, VARIABLE SIZE	0	0	0
126I MOBILITY UNIT, PROT. CORRIDOR	22.7	0	56.6

TABLE 2-4. LIST OF ABBREVIATIONS  
USED IN THE SPECIFICATION SHEETS

A	amp
a.c.	alternating current
BMMD	Body Mass Measurement Device
°C	Centigrade (degrees)
cc	cubic centimeter
CDMS	Command & Data Management System
cm	centimeter
D	depth dimension
dB	decibel
d.c.	direct current
dm	decimeter
ECG	electrocardiogram
EC/LSS	environmental control/life support system
ECS	environmental control system
EEG	electroencephalogram
E.I.	equipment item
EMG	electromyogram
EPS	electrical power system
E.U.	equipment unit
°F	Fahrenheit (degrees)
fpm	feet per minute
F.S.	full scale
ft <sup>3</sup>	cubic feet
g	grams
H	height dimension
Hz	hertz
IC	integrated circuit
IR	infrared
in.	inch
k	kilo - (thousand) or thermal conductivity
°K	Kelvin (degrees)
kg	kilogram
kw	kilowatts
l	liters
LBNP	Lower Body Negative Pressure (Device)
LiOH	lithium hydroxide
LN <sub>2</sub>	liquid nitrogen
LSPS	life support & protective systems
LSS	life support system

TABLE 2-4. LIST OF ABBREVIATIONS  
USED IN THE SPECIFICATION SHEETS (Cont'd)

m	meter or milli-
M	meg-
MSI	Man Systems Integration
n	nano-
nm	nanometer
N	newton
NASA/ARC	NASA/Ames Research Center
NASA/JSC	NASA/Johnson Space Center
NASA/MSFC	NASA/Marshall Space Flight Center
OGI	oculogyral illusion
r	roentgen
RLC	rotating litter chair
RH	relative humidity
RQ	respiratory quotient
rpm	revolutions per minute
SMMD	specimen mass measurement device
TBD	to be determined
TC	thermocouple
UCSD	University of California at San Diego
V	volt
VCG	vectorcardiogram
VHF	very high frequency
w	watts
0-g	zero gravity
1-g	one gravity
$\mu$	micro (one millionth)

## E.I. 1 ACCELEROMETER

(E.U. 3 Life Sciences Experiment Support Unit.)

### Purpose

These accelerometers are also used to monitor accelerations and vibrations to which human test subjects are exposed during various MSI tests. They may also be attached to appropriately-mounted individual organism cages to sense when the organism is active and to indicate the gross activity level. Acceleration measurement in all three axes is desirable.

### Requirements

Accuracy:  $\pm .0004$  g  
Freq. Resp.: 0 - 100 Hz

### Hardware Status

Rating: Re-package

This item is available and should be usable as is.

### Technical Description

One model of an accelerometer which could possibly be used was chosen and is described on the following pages.

Weight: 0.1 kg (0.2 lb)  
Volume:  $0.03 \text{ dm}^3$  ( $0.001 \text{ ft}^3$ )  
Power: negl.

Development Time - 4 months.

### Comment

Acceleration measurements may be an undesirable way to monitor animal activity since a cage mounting design would be required to vibration isolate all adjacent cages from one another.

## ENDEVCO PRODUCT DATA



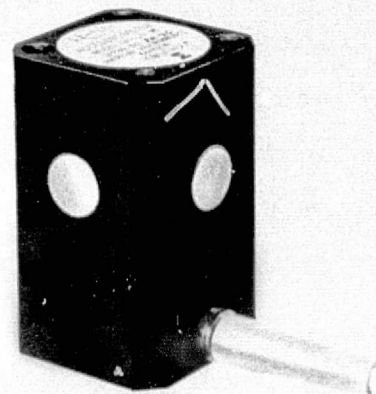
Q-FLEX MODEL QA-116-16

## ULTRA SENSITIVE LINEAR ACCELEROMETER

The Model **QA-116-16** Q-Flex Accelerometer is a rugged  $\pm 1g$  full scale 1 volt per g device for measuring infinitesimal steady state and low frequency acceleration with exacting accuracy. The ability to perform these measurements with high reliability and repeatability over a wide range of environmental variations makes the **QA-116-16** ideally suited for a multitude of subtle motion sensing applications.

Combining outstanding dynamic performance with the ability to withstand, without degradation, static overloads up to 100g and shocks up to 500 times full scale makes the **QA-116-16** a truly complementary addition to the list of desirable motion measuring instruments.

Typical applications for the **QA-116-16** include the measurement of earth motion, structural sway, building vibration, and other minute acceleration forces wherever ultra low resolution and high sensitivity are required.

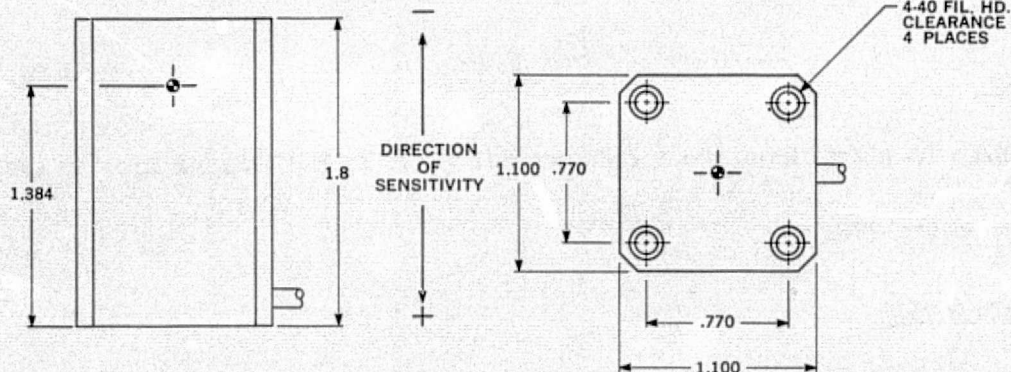


### SPECIFICATIONS FOR THE MODEL OA-116-16 ACCELEROMETER

(TERMINOLOGY PER ISA RP 37.1)

Range (Full Scale) .....	$\pm 1g^*$
Sensitivity (Nominal) .....	1 Volt/g
Output Resistance (Nominal) .....	900 ohms
Frequency Response ( $\pm 5\%$ ) .....	DC to 300 Hz
Natural Frequency (Nominal) .....	1000 Hz
Noise (Nominal): 0 - 10 Hz .....	100 microvolts rms
0 - 300 Hz .....	500 microvolts rms
300 - 10 KHz .....	3 mV rms
Broadband .....	5 mV rms
Excitation Voltage .....	28 VDC $\pm 5\%$
Excitation Current .....	17 ma quiescent, 25 ma full scale
Sensitivity Shift With Excitation Voltage .....	0.005 %/V
Zero Shift With Excitation Voltage .....	50 micro g/V
Resolution (DC) .....	0.000001g
Threshold (DC) .....	0.000001g
Linearity (DC) .....	0.01 % of loading
Hysteresis (Less Than) .....	0.001 % of full scale
Repeatability .....	0.03 % of full scale
Zero Unbalance (Less Than) .....	0.05g
Damping (Approximate) .....	0.6
Thermal Zero Shift (Max.) .....	0.0002g/ $^{\circ}$ F
Thermal Sensitivity Shift (Max.) .....	0.01 %/ $^{\circ}$ F
Transverse Sensitivity .....	0.002g/g

\*Unit meets all specifications at input up to 3 times fullscale.

**NOTES:**

- ⊕ Represents CG of seismic mass  
All dimensions are in inches

**CHARACTERISTICS****ELECTRICAL**

Connection.....	Integral 24 inch shielded four conductor cable, tinned leads
Grounding.....	Electronics are isolated from case 50 megohms at 50 vdc. Shield is common to case

**PHYSICAL**

Weight.....	3.6 ounces (excluding cable)
Sensing Element.....	Q-Flex
Mounting.....	Integral to case
Case Material.....	Stainless steel and anodized aluminum
Accessories Supplied.....	Mounting screws, instruction manual and calibration card

**ENVIRONMENTAL**

Temperature.....	-45°F to +185°F
Static Overload.....	100 g
Shock.....	500 g, 11 millisecc half sine all axes
Vibration.....	50 g pk. random sine all axes
Humidity.....	Unit is epoxy sealed

Continued product improvement necessitates that Endevco Corporation reserve the right to modify these specifications and/or prices without notice.

**RELIABILITY:** Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

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E.I. 1A ACCELEROMETER COUPLER  
(E.U. 3 - Life Sciences Experiment Support Unit)

Purpose

To amplify the signal from the accelerometer (E.I. 1, E.U. 3) for input to the CDMS.

Requirements: TBD.

Hardware Status

Rating: Repackage.

Standard amplifier designs should be usable. A conventional integrated circuit amplifier will result in lower cost than a micro-miniaturized version, and its size and weight will be quite small.

Technical Description

Based on a conventional IC approach, approximate properties are:

Weight:	.05 kg (0.1 lb)
Volume:	0.01 dm <sup>3</sup> (0.0004 ft <sup>3</sup> )
Power:	< 1 watt    28 volt d.c.
Heat Rejection:	< 1 watt
Data Management:	Analog output to RAU, sampling rate will depend upon accelerometer use. Estimated average sampling rate is 500 samples/sec.
Location:	Near accelerometer (E.I. 1, E.U. 3).
Interface:	Electrical connection to accelerometer and CDMS.

Development Time: 4 months.

## E.I. 6 AIR PARTICLE SAMPLER

(E.U. 5 Biochemical and Biophysical Analysis Unit.)

### Purpose

To obtain air particle and micro-organism samples for air quality determinations. Such determinations are necessary for experiment control purposes.

### Requirements

TBD.

### Hardware Status

#### Rating: Modification

Commercial models are available which should be applicable to spacecraft use. A high flow rate model using filter paper for trapping the particles is shown in the attached catalog sheet. The blower motor may require replacement with a 28 volt d.c. motor, and the unit flow rate would probably be reduced for spacecraft/laboratory purposes.

An alternate type of air sampler is the Anderson type of sampler which contains a series of agar-coated petri dishes on which the air flow impinges. Particles and bacteria stick to these dishes and can subsequently be analyzed. The unit described in the attached catalog sheet could possibly be adapted to this mode of particulate capture, if desirable.

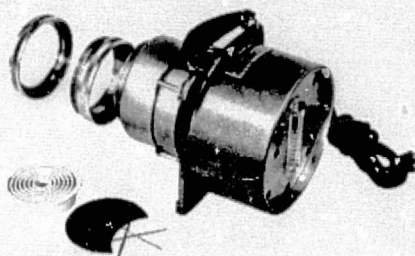
### Technical Description

Estimated properties of a flight type air particle sample collector are:

Weight	2.72 kg (6 lb)
Volume	0.85 dm <sup>3</sup> (0.03 ft <sup>3</sup> )
Power	50 watts

Development Time: 6 months

### Air Sampler



10290-009

**10290-009 AIR SAMPLER, Hi-Volume, Staplex** — For accurately sampling large volumes of air for particulate matter by means of various types of filter paper. A basic instrument in helping combat and control air pollution. Excellent for both indoor and outdoor sampling. Being used to determine factory health hazards, atmospheric conditions, smoke abatement, smog, for mine inspectors, etc. Accurately samples air containing particles as small as 1/100 of a micron in diameter.

The aluminum filter holder accommodates both pleated and flat papers, of which three types are available. Extra interchangeable filter holders are available also. The pump and motor air-mover is a high speed, heavy duty turbine type designed for 24 hour sampling. The fan housing assembly is of cast aluminum. The rate of flow is measured by a variable orifice meter. Portable, field weight 10 lbs. For 115 volts 25/60 Hz.

Each 146.50

### Air Filters

**10291-001 FILTER PAPER for above** — Delivers approximately 18 CFM. Box of 100.

Box 12.60

**10292-004 FILTER PAPER for above** — Delivers approximately 36 CFM. Box of 100.

Box 20.95

**10293-007 FILTER PAPER for above** — Pleated. Delivers approximately 70 CFM.

Lot of 3 2.40

## E.I. 6A AIRFLOW WORK SURFACE

(E.U. 3 Life Sciences Experiment Support Unit.)

### Purpose

This device provides for holding small items in place in 0-g while working with them without the use of special hold-downs.

### Requirements

Estimated preliminary requirements:

Work Surface Size	25 cm × 15 cm (9.8 × 5.9 inches)
Air Velocity	200 fpm

### Hardware Status

Rating: New Development

This item is a conceptual design item.

### Technical Description

The airflow work surface is essentially a perforated surface into which airflows for the purpose of holding small items to the surface by means of the differential pressures created. It may be integrated into the laboratory structure. Estimated properties, including the air blower system are:

Weight	5 kg (11 lb)
Volume	6 dm <sup>3</sup> (0.21 ft <sup>3</sup> )
Power	75 watts

Development Time: 12 months.

## E.I. 7 AUTOANALYZER (MINIATURIZED FAST ANALYZER)

(Previously referred to as GeMSAEC (General Medical Science & Atomic Energy Commission))

### E.U. 5 - Biochemical/Biophysical Analysis Unit

#### Purpose

Provides for rapid photometric analyses of blood serum.

#### Requirements

This device provides the functions of a spectrophotometer. Features of the device which are required for application to the spacecraft environment include: (1) rapid automated data processing, (2) centrifugal sample and reagent handling, (3) small size, weight and power, and (4) small sample and reagent quantities used.

The analyzer should be capable of performing most photometric analyses. Those successfully performed, as listed in the reference cited below, include:

1. Acid and alkaline phosphatase
2. Creatinine phosphokinase (CPK)
3. Lactic dehydrogenase - lactate substrate (LDH-L)
4. Serum glutamate oxaloacetate transaminase (SGOT)
5. Serum glutamate pyruvate transaminase (SGPT)
6. Glucose
7. Blood urea nitrogen (BUN)
8. Serum triglyceride
9. Calcium
10. Total bilirubin
11. Multi-Enzyme: Multi-Sample Analysis

#### Hardware Status

Rating: New development.

This device is being developed by the Oak Ridge National Laboratory (Atomic Energy Commission) for the Biochemistry and Endocrinology Laboratory, Biomedical Research Division, NASA/JSC (Dr. Carolyn Leach). The basic centrifugal rotor/photometric module development is complete as is the computer data processing equipment. Zero-g testing using parabolic KC-135 flights are being planned. Flight packaging and qualification will commence in about 1977. A unit even smaller than the existing prototype is being contemplated for the flight hardware version.

## E.I. 7 AUTOANALYZER (MINIATURIZED FAST ANALYZER) (Cont'd)

### Technical Description

The miniaturized fast analyzer for flight will consist of the plastic cuvette rotor module and an integral microprocessor computer. The original design also included an automated sample and reagent loader and a rotor cleaning station. Instead of these, disposable rotors preloaded with reagent will be used in the flight unit. Blood samples will be injected into these rotors manually. The rotor module incorporates a unique photometric system that utilizes a spinning 17-cuvet plastic rotor to transfer and mix a parallel series of samples and reagents into their respective cuvettes. The motion of the rotor (up to 5000 rpm) is further utilized to rapidly move the cuvettes through a stationary optical lamp and detector system. The temperature of the samples in the cuvette rotor are automatically monitored and controlled to 303°K (30°C). All data is analyzed internal to the unit by an integral microprocessor computer. The output is printed out on a digital printer.

Estimated properties of the flight-qualified autoanalyzer were based upon the current prototype unit properties.

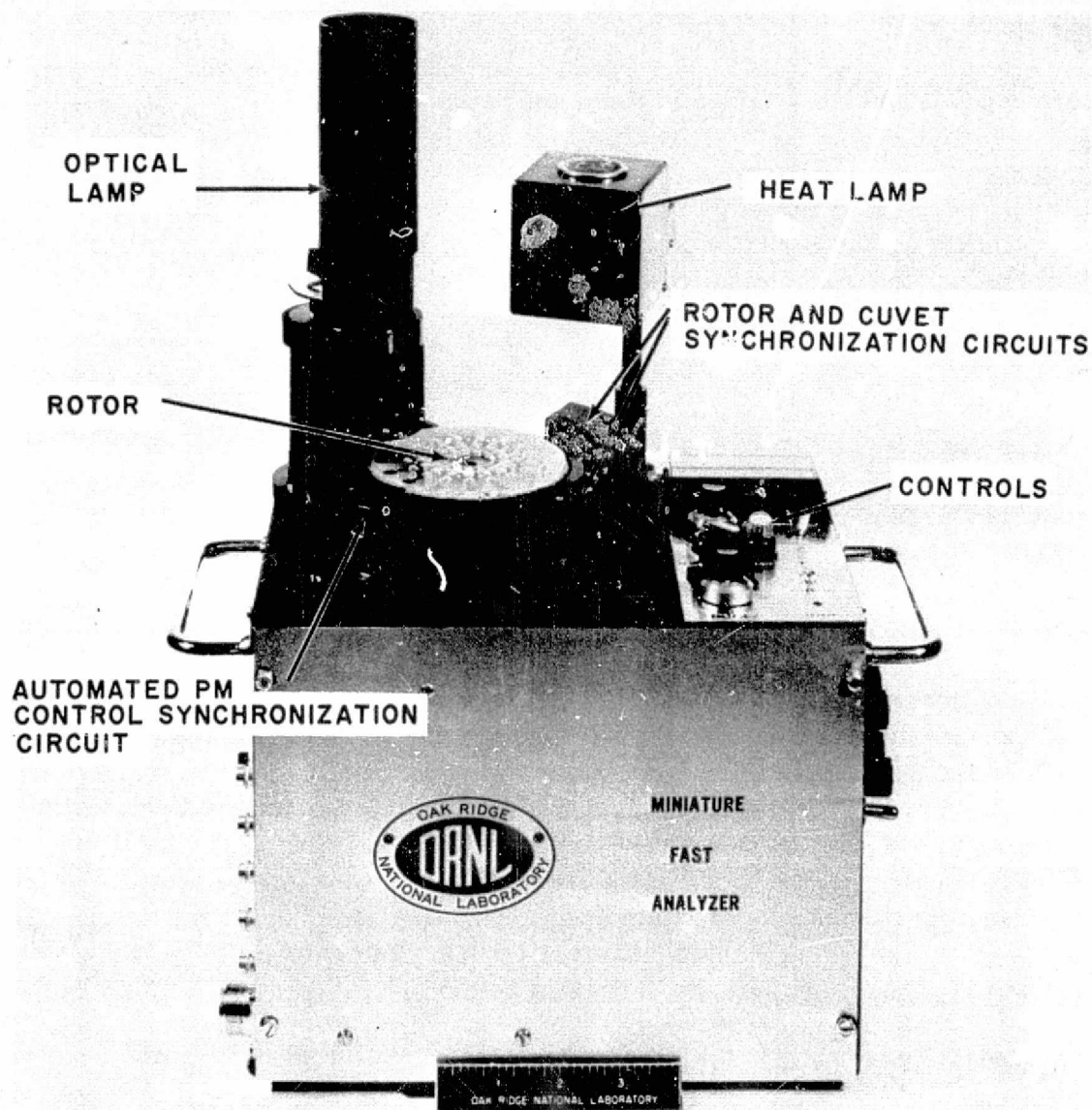
Weight:	
Fixed equipment:	23 kg (50.7 lb)
Rotors for 7 days:	3 kg (6.6 lb)
Total for 7 days:	26 kg (57 lb)
Volume:	40 dm <sup>3</sup> (1.41 ft <sup>3</sup> )
Power:	200 watts (currently 115 volt a.c. but could be converted to 28 volt d.c.)
Heat Rejection:	200 watts (air cooling assumed)
Data Management:	No data processing required. Digital output results could be handled by the CDMS for storage and/or transmission to ground.
Location:	Autoanalyzer must be located where the ambient temperature is not more than 300°K (27°C). The analyses are made at 303°K (30°C) and the unit only has heating capability.

E.I. 7 AUTOANALYZER (MINIATURIZED FAST ANALYZER) (Cont'd)

Development Time: 24 months.

References:

- (1) Telecon with Larry Wallace, NASA/JSC, 713/483-4086.
- (2) Gravity Zero Analytical Clinical Laboratory System, Annual Program Report for the Period April 15, 1972, to May 1, 1973, Report No. ORNL-TM-4225, Oak Ridge National Laboratory, Oak Ridge, TN, July 1973.



Miniature Fast Analyzer

## E.I. 7A AUTOMATED POTENTIOMETRIC ELECTROLYTE ANALYZER

(E.U. 5 Biochemical and Biophysical Analysis Unit.)

### Purpose

To measure gases and electrolytes in blood and urine samples.

### Requirements

This equipment item has been developed for NASA/JSC by Orion, Inc., especially for spaceflight use. The characteristics of this analyzer are presented below.

### Hardware Status

Rating: SRT

A flight prototype of the automated potentiometric electrolyte analyzer is currently undergoing evaluation at NASA/JSC. The unit was constructed under NASA contract NAS9-12117. It is shown and described in the attached NASA Technical Brief.

### Technical Description

This analyzer processes a 1 ml blood sample to measure pH,  $pCO_2$ , Na, K, Cl, ionized Ca and total Ca. A modified version is anticipated which will be capable of additional measurements of  $pO_2$  and glucose. The prototype analyzer is comprised of 4 units. These are: (1) a teletype machine, (2) a Digital Equipment Corp. PDP-8 digital computer, (3) an electronics unit, and (4) a fluid transport unit. In flight, the capability provided by the teletype and the digital computer can be provided by the supporting spacecraft control and data management subsystem digital readouts and computer. Alternately, a dedicated miniaturized data processor could be built. Characteristics of the flight unit are estimated below:

Weight:	12.7 kg (28.0 lb)
Volume:	$57 \text{ dm}^3$ ( $2.0 \text{ ft}^3$ ) (possibly smaller)
Power:	100 watts

The unit contains consumable reagents, reported to be about 2 liters for a total of 100 analyses. This number of analyses was assumed to be adequate for 7-day missions. Extra reagent will depend upon the specific experiments being conducted.

Development Time: 12 months.

# NASA TECH BRIEF

## *Lyndon B. Johnson Space Center*

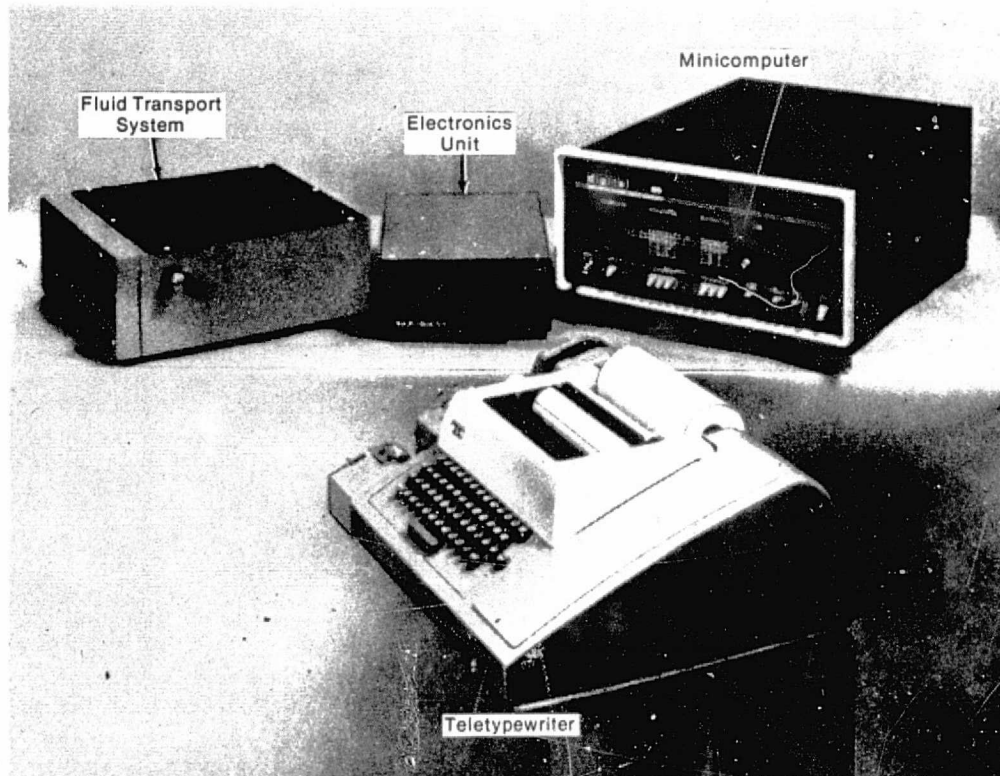


NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### Portable Automatic Blood Analyzer

To meet the requirements of biomedical research in space, NASA's Johnson Space Center has sponsored the development of a compact and potentially-portable, automatic blood-analysis system (see figure). Automatic blood analyzers are currently being used in large hospitals that require the fast and reliable determination of blood chemistry. A commercial version of the compact system designed for the space program could make such services available on a much broader basis. The entire system occupies only a few cubic feet of space and can operate from a portable power supply.

The automatic blood analyzer employs chemical-sensing electrodes for the determination of blood gas and ion concentrations. It is rugged, easily serviced, and comparatively simple to operate. The system can analyze up to eight parameters. The design model automatically determines the levels of pH,  $p\text{CO}_2$  (the negative log of  $\text{CO}_2$  concentration), sodium ( $\text{Na}^+$ ), chloride ( $\text{Cl}^-$ ), potassium ( $\text{K}^+$ ), ionized calcium ( $\text{Ca}^{++}$ ), and total calcium. The system can be modified to measure other blood constituents including nonionic species, such as urea, glucose, and oxygen.



Automatic Blood Analyzer

The system consists of four major subsystems: a fluid transport system, an electronics unit, a controller (minicomputer), and a teletypewriter. The fluid transport subsystem contains all components necessary to standardize, inject, store, deliver, measure, and dispose of test samples and reference standards. These include standard solution bags, a septum inlet port, a chromatographic switching valve, a sample-holding loop, reagent bags, electrodes, pumps, and a waste bag.

The fluid transport subsystem also includes eight amplifiers (one for each parameter), an eight-input multiplexer to select a specific amplifier output, and temperature measurement and control circuits. All of this circuitry is on a single printed-circuit board and is included in the fluid transport system because it should be kept close to the sensing electrodes. The remaining circuitry is included in the electronics unit.

The electronics unit contains most of the logic and control functions required for interface with a digital computer. Control signals from the computer are converted to the appropriate driving voltages for valves, the pump, the mixer, and the multiplexer in the fluid transfer system. The electronics unit also provides power for itself and the fluid transport system and digitizes all system-status data from the fluid transport unit to feed back to the computer.

The controller and the teletypewriter comprise the operating system. The controller is a general-purpose minicomputer with a 12-bit-word digital processor, two 4096-word memory banks, and an internal, adaptable interface system. Analyses of part or all of

the system-analyzable components of a test sample may be selected in any order, and results are printed on the teletypewriter.

This rugged compact system is easy to operate because all reference solutions are automatically restandardized every sample cycle, eliminating the need for continued adjustments by the operator. In addition, all reagents and waste receptacles are contained within the system, and snap-in modules and leak-free connectors are used for convenient servicing.

**Note:**

This method is described in the following report:  
"Automated Potentiometric Electrolyte Analysis System"

Reference: NASA CR-134373 (N74-30491).

This report may be obtained from:

National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$7.00  
(or microfiche \$2.25)

**Patent status:**

NASA has decided not to apply for a patent.

Source: R. L. Coleman of  
Orion Research, Inc.  
under contract to  
Johnson Space Center  
(M5C-14627)

## E.I. 11 ANALYZER, GENERAL SPECTROPHOTOMETER (E.U. 5 - Biochemical & Biophysical Analysis Unit)

### Purpose

This is a general purpose instrument for biolaboratory spectral analysis of gases and liquids. It can also be used to determine the spectral properties of illuminated solids and light sources. The Autoanalyzer (GeMSAEC) (E.I. 7, E.U. 5) performs some of the same functions of a spectrophotometer but is designed for specific blood serum analysis. However, the Autoanalyzer may satisfy the requirements of many of the Spacelab life sciences laboratories so that the general purpose spectrophotometer would not be needed. The latter device will most likely be needed only in comprehensive laboratories which will fly later in the Spacelab program.

Requirements - TBD.

### Hardware Status

Rating: Redesign.

Many commercial units are available, but would require redesign for operation in null gravity. A Cary Model 14 was recommended by UCSD scientists as one of the best high resolution instruments for biolaboratory use. Its wavelength range is 186 to 2650 n.m. but it weighs 270 kg (600 lb), occupies 0.78 m<sup>3</sup> (28 ft<sup>3</sup>) and requires up to 800 watts. Several catalog sheets on this unit are attached.

Beckman spectrophotometers were also mentioned by the UCSD consultants as acceptable units. A Beckman Model 24 Spectrophotometer is a more limited capability candidate and has a wave length range of 190 to 700 n.m. This instrument was the subject of comprehensive Beckman testing to determine its suitability for use in spaceflight, see reference cited below. Several sheets from this reference are attached. As indicated in the writeup, the major problem in operating a spectrophotometer in null gravity is the liquid sample handling. See the attached sheet from the Beckman report for further discussion of this problem.

### Technical Description

For purposes of preliminary analysis and conceptual design, the properties of the Beckman Model 24 are used herein.

#### E.I. 11 (Cont'd)

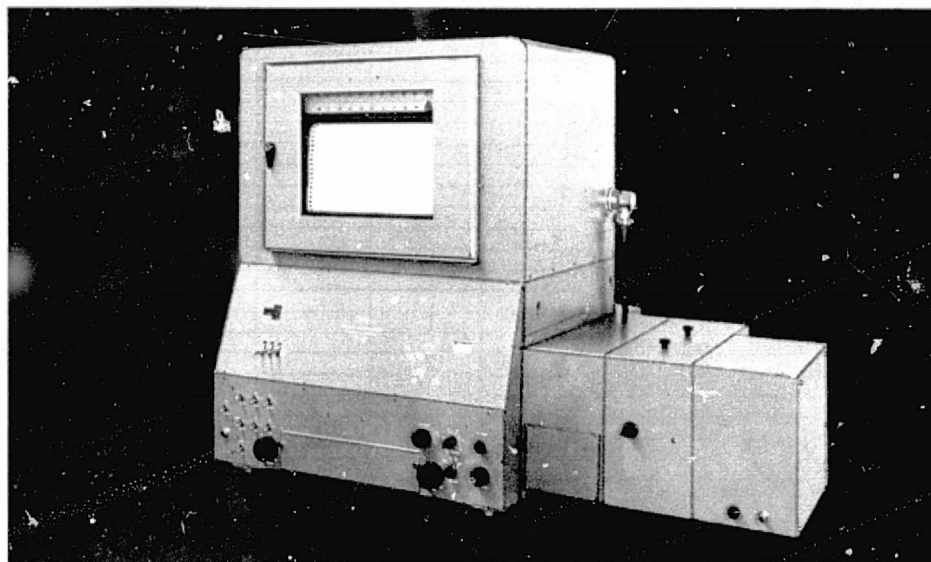
Weight:	30 kg (66 lb)
Envelope Dimensions:	6.1 dm W × 4.1 dm D × 3.6 dm H (24" W × 16" D × 14" H)
Envelope Volume:	90 dm <sup>3</sup> (3.2 ft <sup>3</sup> )
Power:	240 watts, 120 volt a.c. (could be converted for d.c. operation)
Heat Rejection:	240 watts (forced air convection cooled)
Data Management:	TBD
Location:	In Spacelab double rack
Interface:	EPS & CDMS

Development Time - 12 months.

#### Reference

Analysis of Multipurpose Equipment for Space Application, Contract NAS8-29776,  
Beckman Instruments, Inc., Advanced Technology Operations, Anaheim, CA,  
10 December 1973.

# CARY 14 Recording Spectrophotometer



Because of built-in versatility and a variety of accessories and modifications, the CARY 14 has proved of value in almost all areas of spectrophotometry. The standard instrument can be used for fixed-wavelength kinetic studies, or for recording absorbance or transmittance spectra, linearly in wavelength. It provides excellent performance for measurements made over the wavelength range 1860Å to 2.65  $\mu$ . Accessories are available for flame, fluorescence, reflectance and other studies. Standard modifications are available for near infrared studies of heated or photosensitive samples, or for scanning samples up to 1000°C with no loss of photometric accuracy.

## PERFORMANCE

**Wavelength Range:** 1860Å-2.65  $\mu$ .

**Wavelength Accuracy:** Better than 4Å throughout most of range.

**Wavelength Reproducibility:** Better than 0.5Å.

**Resolving Power:** 1Å in most of UV-visible range; 3Å in near infrared range.

**Photometric Accuracy:** Within 0.002 abs at 1.0 abs; 0.005 at 2.0 abs. 0.0005 abs with expanded scale.

**Photometric Reproducibility:** 0.002 abs on standard range, 0.0005 abs with 0-0.1 scale.

**Photometric Ranges:** Selection of absorbance or transmittance scales available. Standard unit equipped with dual 0-1, 1-2 absorbance slidewire with automatic range change.

**Dual Range Recorder:** Takes advantage of the greater photometric accuracy of the flicker-beam photometer. With the automatic range change, absorbance scale and chart are effectively 20 in. (50 cm) wide.

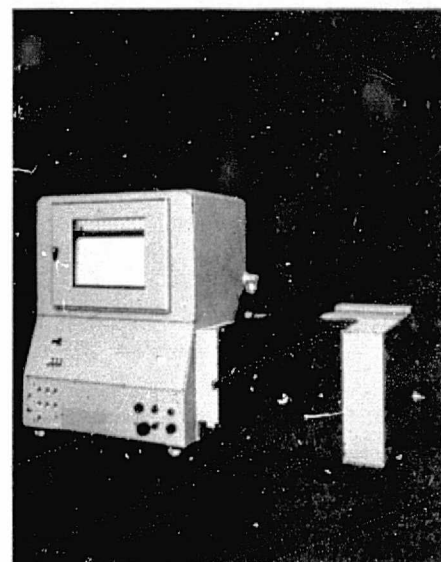
**Zero Stability:** Less than 0.001 abs per hour drift.

**Light Purity:** Stray light is less than 0.0001% between 2400Å and 5000Å, and 0.1% at range limits.

**General Construction:** The CARY 14 is housed in an aluminum alloy case finished with gray baked epoxy. It occupies a space 47 in. (118 cm) long, 30 in. (75 cm) wide and 35 in. (88 cm) high and weighs about 600 pounds (270 kg).

**Utilities:** The CARY 14 operates from 115V, 50 or 60 Hz; no batteries are necessary. The maximum current consumed is 8 A. The accuracy of the instrument is not impaired by voltage variations of  $\pm 10\%$  or frequency variations of  $\pm 1\%$ . For voltage or frequency variations outside this range, consult the factory. The hydrogen and infrared lamps require a reliable source of cooling water at the rate of  $\frac{1}{2}$  gal (2 liters) per minute.

If you wish to use the instrument below 2000Å, the monochromator, detector and

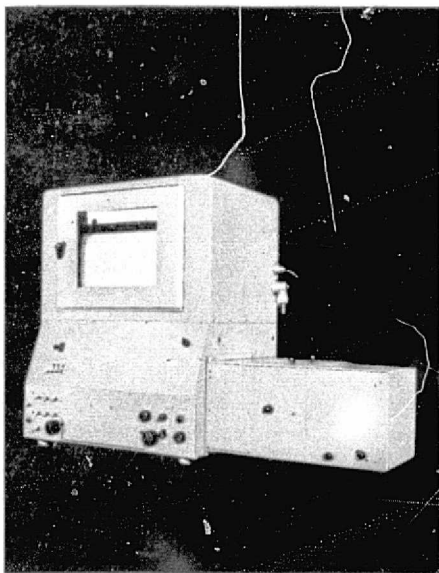


sample compartments should be purged with dry nitrogen gas.

## CARY 14H

The CARY 14H, a special modification of the CARY 14, enables the operator to accurately record samples at high temperatures. Particularly designed for the study of fused salts, it is ideally suited to all high temperature applications. The large cell area, small beam dimensions and mode of operation extend its usefulness to many other applications, including photoreaction studies, Zeeman effect measurements, high-pressure work, radiation studies, light-scattering properties and work with odd-shaped samples. Performance specifications are identical with the CARY 14, except in cell radiation: Photometric error of absorption measurements due to thermal radiation from cells up to 1000°C is less than 0.001 abs at zero. Cells with temperatures above 1000°C may be used at some sacrifice of signal-to-noise ratio. Resolving power is 1.5Å over most of the UV-visible range; 4Å in near infrared range. Stray light is less than 0.001% over most of the range, 0.1% at range limits.

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**CARY 14R**

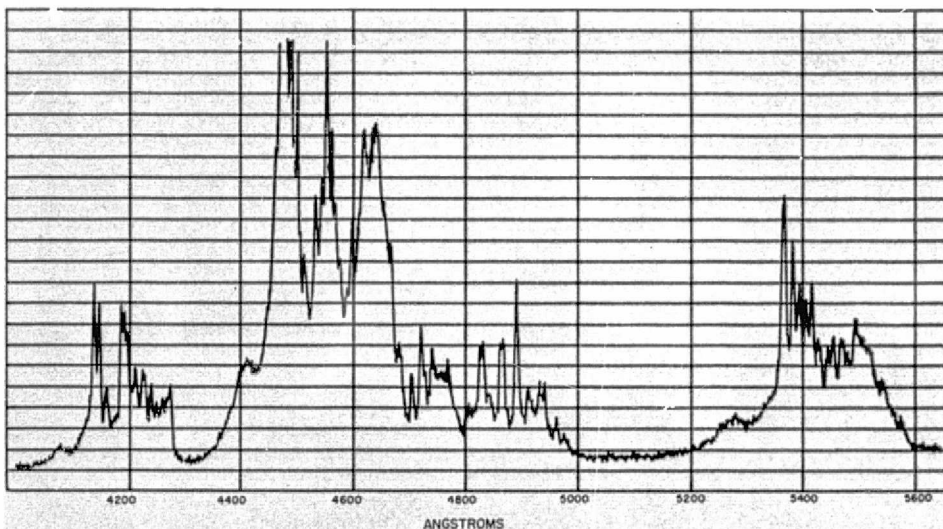
The CARY 14R permits near infrared analysis of heat-sensitive or photosensitive samples which should not be exposed to undispersed radiation. Operational specifications are the same as for the CARY 14.

**CARY 14RI**

The CARY 14RI is similar in purpose and characteristics to the 14R except for use of Infrasil transmission optics which allow operation from 2250Å to 3.0  $\mu$ . Moreover, for improved resolution and greater energy in the near infrared, the grating blaze has been changed from 3000Å to 7500Å. Specifically designed for studies extending into the near infrared, several applications may be found in the solid-state field; for example, many semiconductors have absorption edges in the near infrared. Most lasers, including gas lasers, emit in this region, and the related absorption and fluorescence phenomena require measurement in the near infrared.

#### Resolution is better than:

1  $\text{cm}^{-1}$  from 1.5 to 3  $\mu$ ;  
2  $\text{cm}^{-1}$  to 0.9  $\mu$ ;



#### Powdered Holmium Oxide Spectrum

This spectrum of powdered holmium oxide illustrates the sharpness of peaks provided by a molecule in an ordered and rigid state. As with some gases most of the bands observed cannot be completely resolved by the instrument. It illustrates the high resolution capabilities of the CARY 14 under low light level conditions such as in micro samples or low transmission. Instrument conditions are as follows: Sample: Powdered Holmium Oxide ( $\text{Ho}_2\text{O}_3$ ). Slit: 1/3 height. Gain: Tap 5. Slit Control: 50.

1Å throughout the visible region.

Because of optimized near infrared performance, this necessarily leads to some degradation of the ultraviolet performance.

In the ultraviolet, resolution at a fixed signal-to-noise ratio is reduced because of the characteristically low grating efficiency on the short wavelength side of the blaze. It reaches a minimum at about 40% of the blaze wavelength. Below 3500Å the CARY 14RI spectral slitwidths may be two to five times greater than those for the standard CARY 14.

These resolution values may be obtained with a one-second period and with a signal-to-rms-noise ratio of 1000.

**Stray light limits:** 0.0001% in visible region;  
0.0002% at 1.7  $\mu$ ;  
0.02% at 2.8  $\mu$  and 2300Å.

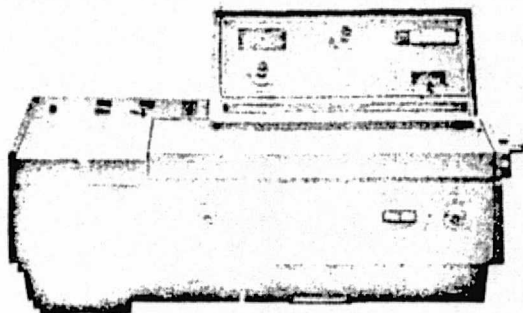
All other specifications are the same as the CARY 14 Recording Spectrophotometer.

Chart Speed Inches/Min	5	4	3	2	1.33	1
Scan Speed Angstroms Per Sec	Angstroms Per Division					
.5	2	2.5	3.3	5	7.5	10
2.5	10	12.5	16.6	25	37.5	50
5	20	25	33.3	50	75	100
10	40	50	66.6	100	150	200
25	100	125	166	250	375	500
50	200	250	333	500	750	1000
100	400	500	666	1000	1500	2000
500	2000	2500	3333	5000	7500	10000

#### SPEED AND VERSATILITY

The table shows the wide range of spectral displays attainable with the various scanning speeds and chart speeds provided on the CARY 14, 14H, 14R and 14RI. Good resolution and accuracy are attainable at fast speeds.

## BECKMAN 24 SPECTROPHOTOMETER



## ELECTRICAL

	INSURMOUNTABLE PROBLEM	MAJOR IMPACT ON MISSION GOALS	DESIGN MODIFICATION REQUIRED	MANUFACTURING MODIFICATION REQUIRED	POST-MANUFACTURING MODIFICATION REQUIRED	NO MODIFICATION REQUIRED
POWER CONVERSION			X			
POWER DISSIPATION						X
SUSCEPTIBILITY TO EMI			X			
EMISSION OF EMI *						
GROUNDING				X		
HUMIDITY				X		

## THERMAL

HOT SPOTS (PERSONNEL SAFETY)						X
HOT SPOTS (COMPONENT FAILURE)						X
TOTAL HEAT LOAD						X
HEAT TRANSFER						X

## CHEMICAL

FLAMMABILITY *						
OUTGASSING						X

## MECHANICAL

VIBRATION				X		
SHOCK				X		
ACCELERATION					X	
SAFETY					X	
MOUNTING					X	
STORAGE					X	
PROTECTION					X	
MASS						X
SIZE						X
GRAVITY-DEPENDENT COMPONENTS				X		

## OPERATIONAL

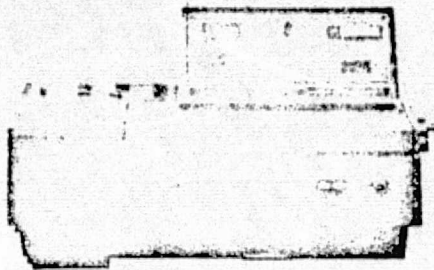
SOURCE HANDLING					X	
CALIBRATION					X	
SERVICE					X	
HUMAN FACTORS					X	

## INTERFACE

MECHANICAL					X	
THERMAL						X
ELECTRICAL				X		
VACUUM			X			

\* FURTHER TESTING REQUIRED

# BECKMAN 24 SPECTROPHOTOMETER



## ELECTRICAL

	INSURMOUNTABLE PROBLEM	MAJOR IMPACT ON MISSION GOALS	DESIGN MODIFICATION REQUIRED	MANUFACTURING MODIFICATION REQUIRED	POST-MANUFACTURING MODIFICATION REQUIRED	NO MODIFICATION REQUIRED
POWER CONVERSION			X			
POWER DISSIPATION						X
SUSCEPTIBILITY TO EMI			X			
EMISSION OF EMI *						
GROUNDING				X		
HUMIDITY				X		

## THERMAL

HOT SPOTS (PERSONNEL SAFETY)						X
HOT SPOTS (COMPONENT FAILURE)						X
TOTAL HEAT LOAD						X
HEAT TRANSFER						X

## CHEMICAL

FLAMMABILITY *						
OUTGASSING						X

## MECHANICAL

VIBRATION				X		
SHOCK				X		
ACCELERATION					X	
SAFETY					X	
MOUNTING					X	
STORAGE					X	
PROTECTION					X	
MASS						X
SIZE						X
GRAVITY-DEPENDENT COMPONENTS				X		

## OPERATIONAL

SOURCE HANDLING					X	
CALIBRATION					X	
SERVICE					X	
HUMAN FACTORS					X	

## INTERFACE

MECHANICAL					X	
THERMAL						X
ELECTRICAL				X		
VACUUM			X			

\* FURTHER TESTING REQUIRED

Section 4 - Specific Instrument Study Results

Subsection 4.4 - Beckman Model 24 Spectrophotometer

DESCRIPTION AND OPERATION OF THE BECKMAN 24 SPECTROPHOTOMETER

The Beckman Model 24 Spectrophotometer is a double-beam, digital reading or recording instrument that can make absorbance, concentration, and differential absorbance measurements.

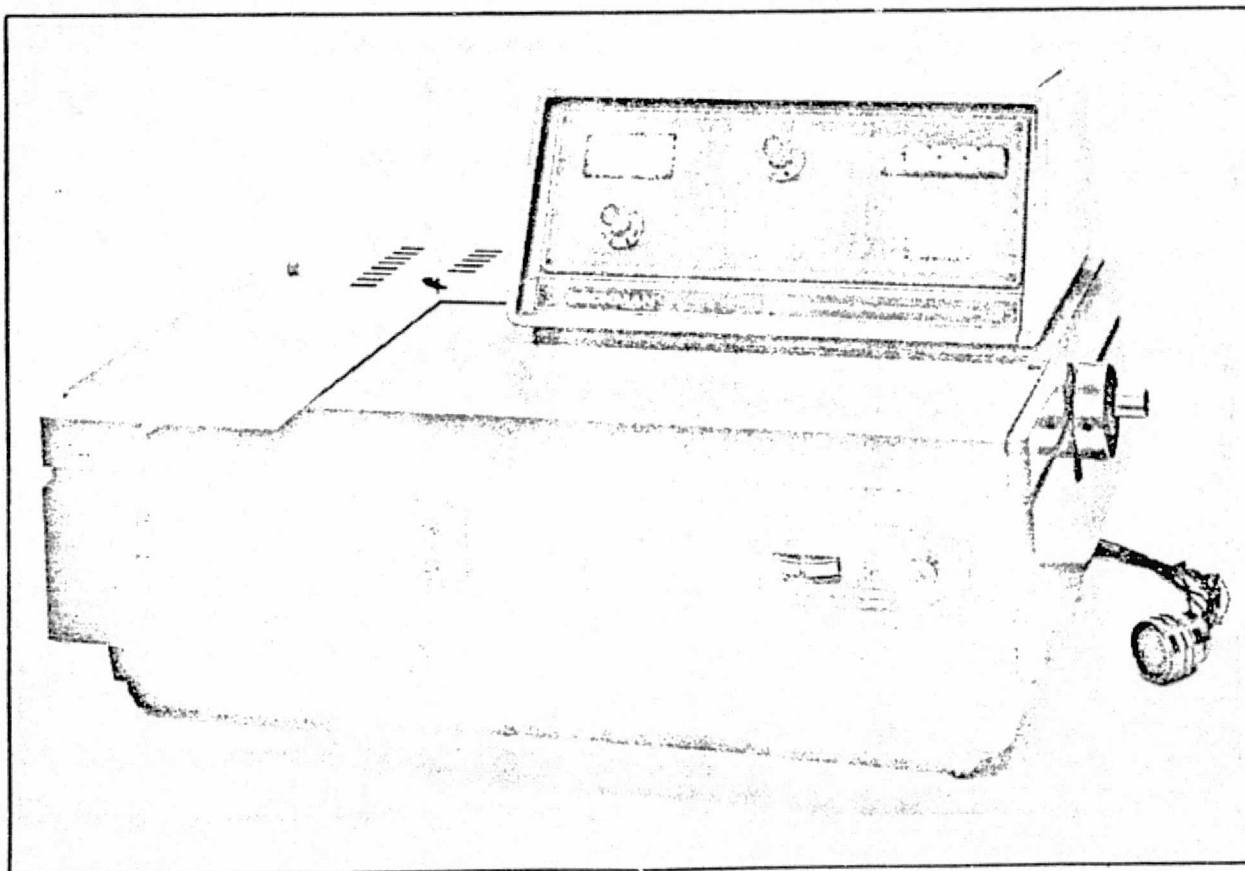
The Beckman spectrophotometer is a versatile device whose specialized features make it a likely candidate for Sortie Lab use. Its features are summarized in the table.

An outline drawing of the Beckman 24 is shown in the accompanying figure. The instrument has overall dimensions 0.61 m (24 in) long x 0.41 m (16 in) deep x 0.36 m (14 in) high. The instrument's weight without any extras or options is approximately 25.9 kg (70 lb).

The instrument is mounted in a compact case whose major design features include: two sources (tungsten and deuterium), power supplies, monochromator, detector, large sample compartment, variable slit control, slit program selector, solid-state circuitry, and a built-in aperture system.

The instrument requires 120 or 240 V (+10%) in either 50 or 60 Hz and 2 A.

The following topics describe tests and analyses that were performed on the Beckman Model 24 Spectrophotometer.



BECKMAN MODEL 24 SPECTROPHOTOMETER

## OPERATIONAL SPECIFICATIONS

The basic principles of operation and characteristics of the Beckman Model 24 Spectrophotometer make it an instrument of wide applicability.

<u>PARAMETER</u>	<u>VALUE</u>
• Single monochromator	- filter grating, 1200 lines/mm, blazed at 250 nm
• Optical principle	- double-beam and single-beam
• Wavelength range	- 190 to 700 nm
• Wavelength presentation	- linear, digital counter
- repeatability	- better than 0.25 nm
- accuracy	- $\pm 0.5$ nm
• Resolution	- 0.2 nm
• Photometric readout	
- digital display	- 4-digit digital, 0 to 2 Å, or 0 to 8 000 counts in concentration
- recorder	- 100 mV/absorbance unit
- differential	- -0.3 Å to +0.7 Å
- BCD connector	- 0 to 2 Å or 0 to 8 000 counts
• Photometric accuracy	- 0.001 Å
- repeatability	- 0.001 Å
• Recorder scales	- 0.1 Å, 0.25 Å, 0.5 Å, 1.0 Å, 2.0 Å full scale
• Baseline stability	- better than 0.004 Å/hour
• Weight	- 25.9 kg (70 lb)
• Overall dimensions	- 0.61 m (24 in) long x 0.41 m (16 in) deep x 0.36 m (14 in) high
• Power requirements	- 120/240 V ( $\pm 10\%$ ), 50/60 Hz, 2 A

Section 4 - Specific Instrument Study Results

Subsection 4.4 - Beckman Model 24 Spectrophotometer

EVALUATION OF PRIMARY PROBLEM AREAS IN SORTIE LAB APPLICATION

The primary performance problem areas are: susceptibility to power line transients and operation in a humid environment.

Electrical Interference - It was found in tests by Beckman that when the instrument was operated between 100 V to 130 V at 60 Hz in the single-beam mode, there appeared a voltage differential on the  $\pm 0.1$ -A range (max) that accounted for about  $\pm 10\%$  of recorder full scale at 130-V overvoltage. Hence, inaccuracies to  $\pm 10\%$  within 115 V to 130 V can be expected since undervoltage effects were negligible; but, no damage was encountered.

EMI tests were performed using a K&E eraser motor. Temporary inaccuracies of up to  $+450\%$  in the double-beam mode of operation occurred. Although line-induced voltage spikes caused transient digital display inaccuracies of up to  $+71\%$ , they manifested themselves as only approximately  $+3\%$  on the recorder. The recommended action is not to operate the instrument while significant line voltage variations are present.

Temperature Variations - Primary tests in the ambient temperature range  $15^{\circ}\text{C}$  to  $40^{\circ}\text{C}$  showed that at  $40^{\circ}\text{C}$  there occurred a considerable shift in peak height; the variation was due to a temperature sensitive transistor on the 1 g converter board. After resynchronization of the vibrating reed demodulator, no significant effects were noted.

Relative Humidity - Sustained low humidity (0-5%) had no noticeable effects on the Beckman 24 performance. Under high humidity conditions of  $35^{\circ}\text{C}$ , 85% RH, and  $35^{\circ}\text{C}$ , 95% RH, performance was unreliable. Reliable operation was restored when humidity was reduced below  $35^{\circ}\text{C}$ , 85% RH.

Offgassing - Most of the offgassed products were solvents probably used for cleaning or in epoxies, paints, etc. The concentrations decreased somewhat with operating time, indicating that a prebake should be performed. This prebake should be at maximum allowable temperature with either a vacuum or a gas purge. This procedure will take off most of the solvents that would elute at normal operating temperature.

The major problem in operating a spectrophotometer in a zero-g environment is sample handling. Most samples are in a liquid medium. Because there is no gravity vector, liquids do not fill the container they are in to leave a single air-liquid interface; i.e., the gas and liquid phases are randomly dispersed. Since optical analysis is impaired or impossible when bubbles are in the optical path, special provisions will be required to move the sample into and out of the cuvette and exclude bubbles from the optical path. Pumps and syringes can be used for moving fluids. A commercial example of a pump-operated sample-handling system for optical analyses is the Technicon automated biochemistry instrument. The problem of removal of bubbles from the optical path was solved by Beckman in a subcontract to Lockheed on the IMBLMS program. We built a colorimeter for space application which accepted samples in specially designed plastic pouches. The liquid was drawn into the distal part of the pouch, leaving the gas in the proximal part. A special cuvette holder pressed the pouch into a fixed-width chamber, maintaining a constant optical path length.

Shock, Vibration, and Acceleration Loading - Preliminary analysis shows that the delicate chopper assembly would need support during the assumed launch environment. The assembly can be modified by means of a simple mechanical support. Other components that need support are capacitors that are held only by their leads.

## PRIMARY PROBLEM AREAS

The major problem areas with the Beckman Model 24 Spectrophotometer lie in susceptibility to power line transients, EMI, and relative humidity. Consideration must be given to sample handling in zero g also.

Problem Area	Effect	Sortie Lab Limits	Implication	Suggested Action
Line voltage variations 100 to 130 V at 60 Hz (instrument uses 115 V 60 Hz line voltage)	single beam mode voltage differential on 0.1 A range $\pm 10\%$ of recorder full scale	MIL-STD-461A/462/463	inaccuracies to 10% between 115 and 130 V since undervoltage tests were negative	monitor line voltage using calibration scale nomogram
EMI (high frequency interference)	max 0.166 A in double beam mode, output current to recorder		transient inaccuracies of up to 450% in double beam mode	none required since effects are transient
EMI (line voltage spikes and steps at +6 V max)	max +71% variation in digital display with 6 V spike but >3% on recorder		inaccurate and spurious signals	signals are transient
Ambient temperature variation of 15°C to 40°C	at 40°C shift in peak height	21°C to 32°C	test showed variation due to poor synchronization	maintain proper calibration and synchronization as explained in electrical performance topic
Relative humidity (RH)	35°C, 85% RH and 95% RH caused operating failures	0-100% RH	unreliable operation of wavelength drive	study possible use of conformal coating to protect susceptible components
Outgassing	trichloroethylene, n-butanol, chlorobenzene	Meets <u>Federal Register</u> 37, No. 202, Table G-1	well within human endurance levels as specified by <u>Federal Register</u>	none required
chemical sample manipulation in zero g	liquids separate into many droplets which could add to atmospheric contamination	none specified in technical guidelines	liquids must be handled by means of closed vessels as syringes	develop syringe and centrifuge system to handle liquid samples to Model 24 Spectrophotometer
Shock, vibration, acceleration loading	analysis shows that delicate chopper assembly would not pass NASA vibration tests		no support on chopper, internal capacitors, and display tubes	modify instrument with necessary supports

E.I. 14 - ANESTHETIZER, INVERTEBRATES  
(E.U. 70 Invertebrate Holding Unit.)

Purpose

This device will be used to render invertebrate organisms (such as vinegar gnats) insensible in order to facilitate handling.

Requirements

1. Use of CO<sub>2</sub> system preferred due to safety and compatibility with the crew EC/LSS.
2. CO<sub>2</sub> concentration required: 90%.
3. Maximum capacity: Assume 6,000 cc/day. (This will approximately anesthetize organisms in 6-500 cc containers, assuming 2 effective air volume purges to reach 90% CO<sub>2</sub>.)

Hardware Status

Rating - modification.

This item involves the use of a standard gas bottle, valve and plumbing components. Commercial hardware should be usable with some modification.

Technical Description

One simple design would utilize a CO<sub>2</sub> bottle, a valve, and connecting tubing. The critical temperature of CO<sub>2</sub> is 88.4°F and since the storage vessel could conceivably reach this temperature, supercritical storage conditions were assumed in estimating the storage vessel properties below.

	<u>7 Days</u>	<u>30 Days</u>
CO <sub>2</sub> weight:	83 g (0.18 lb)	354 g (0.78 lb)
Total weight (including storage vessel & plumbing)	187 g (0.41 lb)	797 g (1.76 lb)
Power	Negl.	Negl.
Volume of CO <sub>2</sub> bottle (including 20% of CO <sub>2</sub> volume for bottle volume)	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )	2.12 dm <sup>3</sup> (0.07 ft <sup>3</sup> )
Storage bottle pressure	10.3 mN/m <sup>2</sup> (1500 psia)	
Total envelope volume estimate (including plumbing)	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )	2.6 dm <sup>3</sup> (0.09 ft <sup>3</sup> )

Development Time: 6 months

E.I. 14B ANTENNAS, ASSORTED  
(E.U. 2 Data Management Unit.)

Purpose

These antennas are specialized units required for the transmission and reception of biotelemetry signals and reception of electromagnetic field monitoring signals.

Requirements

UHF and VHF types consisting of low profile and conical omnidirectional configurations. These antennas must interface with the holding units and cages, and must be adaptable to microbackpacks.

Hardware Status

Rating: Re-package.

Commercial antennas are available for specialized biotelemetry applications and will require little or no modification. In some cases, VHF whip type antennas may be used. Commercial antennas may only require insulating coatings for use on an organism within a metallic cage.

Technical Description

Low profile or conical omnidirectional antennas tunable to telemetry frequencies of 80 to 300 MHz.

Weight (for several)	0.1 kg (0.2 lb)
Power	0
Volume (for several)	0.03 dm <sup>3</sup> (0.001 cu. ft.)

Development Time: 6 months.

## E.I. 15 ANTHROPOMETRIC GRID

(E.U. 93 Mobility Unit.)

### Purpose

These grids will be used for anthropometric measurements on man or other vertebrate organisms. Grids may be integral with the organism cages to provide measurement capability through the use of video or other types of cameras and optical components.

### Requirements

Small Grids:	5 x 15 cm spaced @ 1 mm
Medium Sized Grids:	50 x 75 cm spaced @ 2 mm
Large Grids:	2 x 2 m spaced @ 5 mm
Extra Large Grids:	4 x 4 m spaced @ 5 mm

### Hardware Status

Rating: Re-package

Ground equipment should be usable with minimum modification.

### Technical Description

Estimated properties for 10 grids are:

Weight:	1.8 kg (4 lb)
Power:	0
Volume:	2.8 dm <sup>3</sup> (0.1 ft <sup>3</sup> )

Development Time: 6 months.

E.I. 15A ATMOSPHERIC SAMPLING SYSTEM  
(E.U. 5 - Biochemical & Biophysical Analysis Unit)

Purpose

To provide for transfer of gas samples from sampling points such as the holding units to gas analyzers such as the Mass Spectrometer.

Requirements

Specific requirements will depend upon individual laboratory requirements as to the number of sampling points, number of analyzers, flow rate requirements, pumping requirements, etc.

Hardware Status

Rating: Redesign.

This system can be designed using commercially available components.

Technical Description

Estimated properties of an atmospheric sampling system for a dedicated life sciences laboratory are:

Weight:	10 kg (22 lb)
Envelope Volume:	28 dm <sup>3</sup> (1 ft <sup>3</sup> )
Power:	20 watts

Development Time : 9 months.

E.I. 19D BODY MASS MEASUREMENT DEVICE  
(E. U. 31 - Biomedical Research Support Unit)

Purpose

To measure the mass of human test subjects.

Requirements

Based upon Skylab body mass measurement device requirements. The device measures up to 100 kg in a 1-g or 0-g environment.

Hardware Status

Rating: Space Qualified.

The Skylab body mass measurement device design should be usable with minor modifications. It was the principal piece of equipment used in Skylab experiment M172.

Technical Description

Data on the Skylab body mass measurement device (BMMD) were taken from the reference cited at the end of this writeup. Body mass determinations are made using a linear spring/mass pendulum platform or "seat". The mass being measured determines the period of the pendulum. The period is electronically timed and converted graphically to direct mass readings.

The BMMD consists of a seat, a spring loading system, and an electronic subsystem module with a digital display and controls. A latch is provided to release the seat from a fixed, spring-loaded position to enable oscillation. The time (period) value measured during the third, fourth, and fifth oscillations is read from the digital display. A leveling device will provide horizontal adjustment to enable proper operation in a one-g environment. A calibration mass adapter is used to mount the calibration mass in the BMMD. The adapter is stowed on the left side of the BMMD frame when not in use. The electronics subsystem electronically times the pendulum and provides direct time readout which will be converted into mass measurements. The electronics subsystem module also houses a temperature sensor and the necessary electronic circuitry to measure and display the temperature of the pendulum spring in degrees Fahrenheit.

The properties of the BMMD are summarized below.

Weight:	36.5 kg (80.5 lb), including calibration mass adapter but not calibration masses. Uses existing equipment for calibration masses.
---------	---

E.I. 19D (Cont'd)

Envelope Dimensions:  $102.9 \times 82.6 \times 79.4$  cm ( $40.5 \times 32.5 \times 31.3$  inches)  
(see Figure)

Envelope Volume:  $675 \text{ dm}^3$  ( $23.8 \text{ ft}^3$ )

Power: 15 watts,  $28^{+2}_{-4}$  volts d.c.

Heat Rejection: TBD - depends upon usage.

Data Management: The BMMD has a six digit readout device which displays the period of oscillation of the mass being weighed and the temperature of the BMMD (for temperature correction). Data are recorded manually and transmitted to ground for the calculation of masses. This data could be handled through the Spacelab CDMS data bus system if desired.

Location: Rigidly mounted and accessible to the crew.

Interfaces: EPS

- Operations:
1. Acceleration is not to be greater than  $1.3 \times 10^{-4}$  g during calibration and  $1.3 \times 10^{-3}$  g during body mass measurement.
  2. Operating temperature limits are 291 to 300°K (65 to 80°F).
  3. Operating voltage limits are:  
Maximum, 30 V d.c. nominal  
" , 33 V d.c. for one second  
Minimum, 24 V d.c. nominal  
" , 21 V d.c. for one second
  4. The operating pressure range is given as 33.1 to 41.4 kN/m<sup>2</sup> absolute (4.8 to 6.0 psia). Recalibration and unit modifications may be required for operation at 1 atmosphere.
  5. Operating relative humidity at 5 psia is given as 30 to 95%.

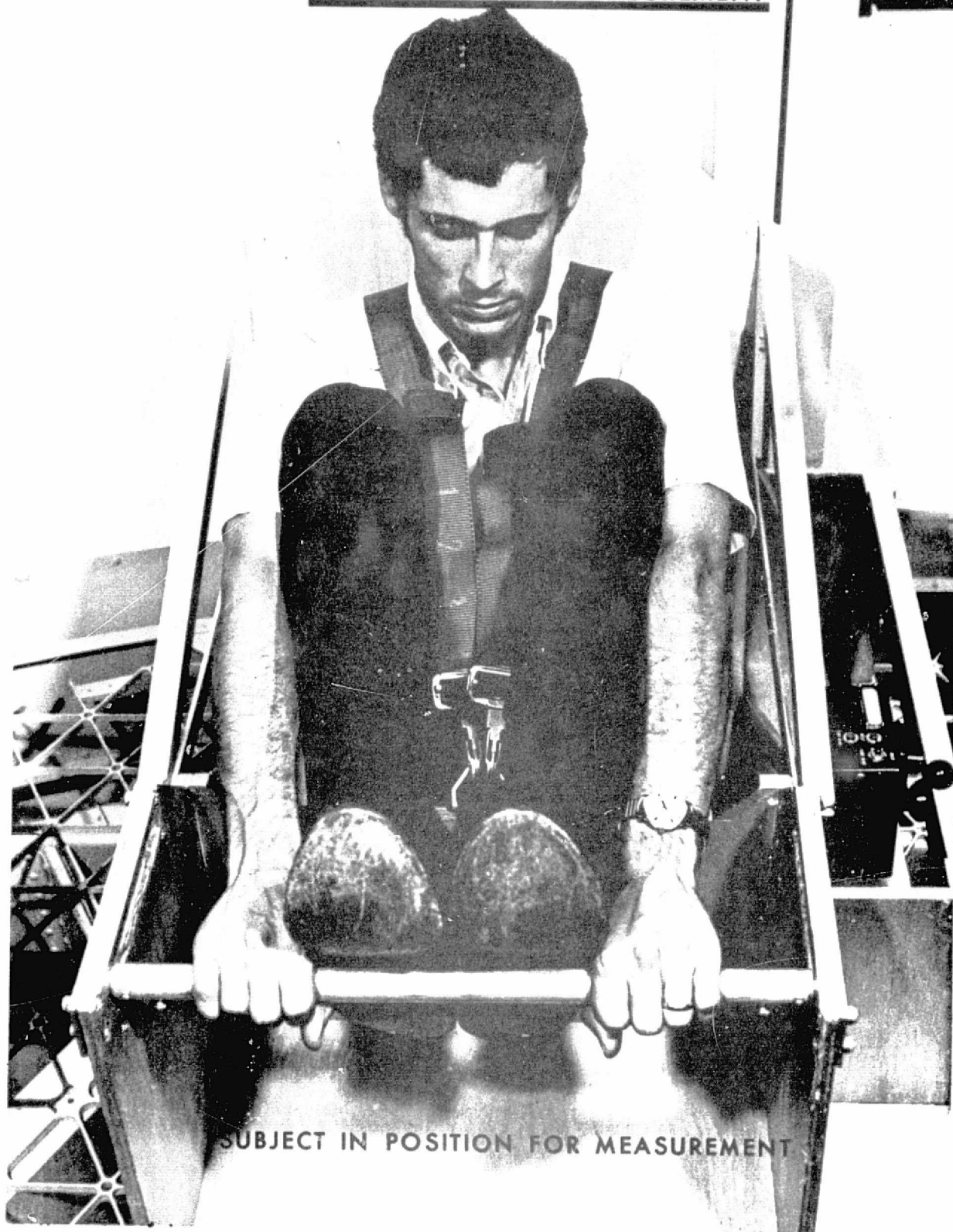
E.I. 19D (Cont'd)

Development Time - 12 months.

Reference

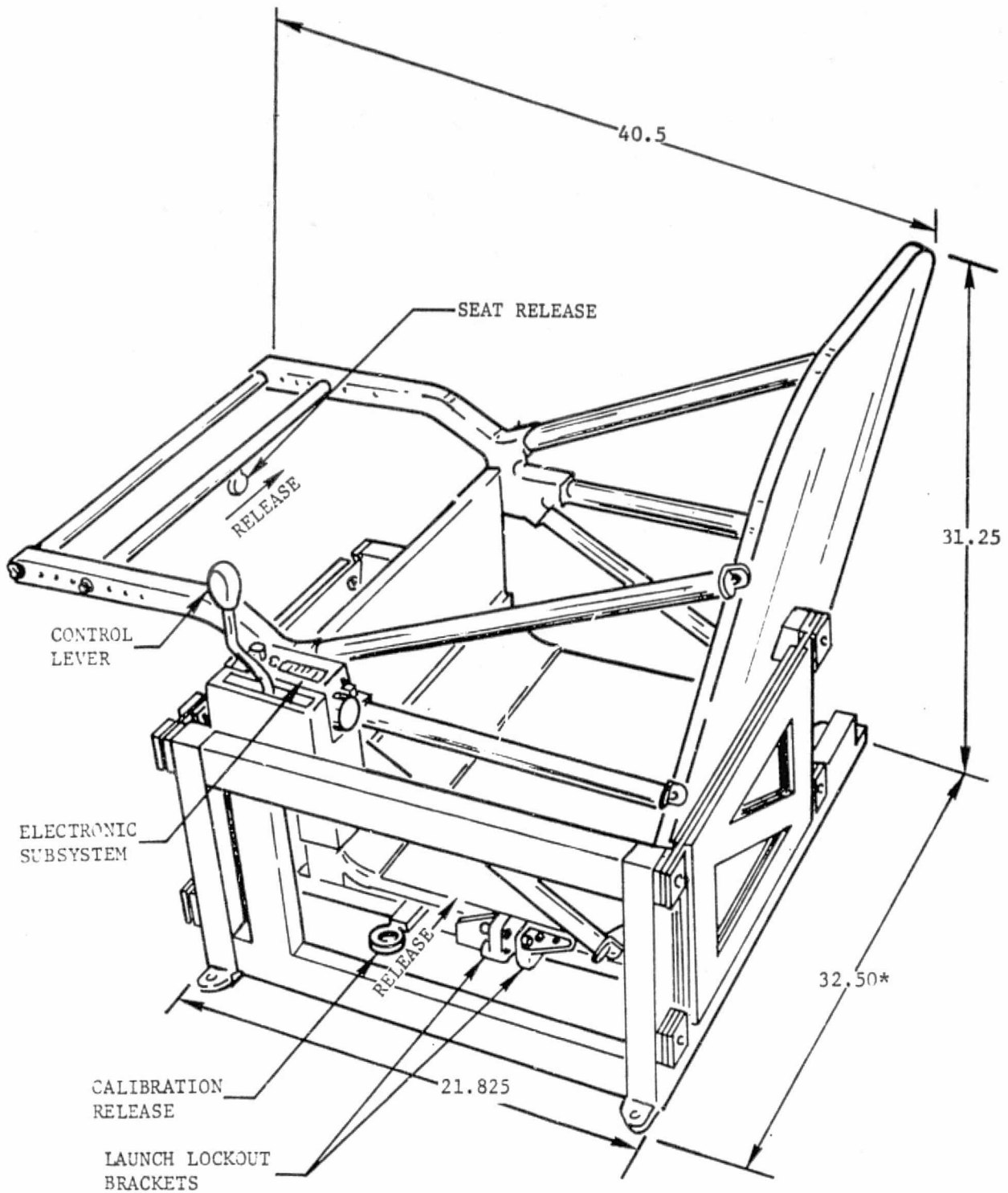
Skylab Program OPERATIONAL DATA BOOK, VOL. I, Part One, Revision A, Report No. MSC-01549 (Vol. I) Rev. A, NASA, Manned Spacecraft Center, Houston, Tex., October 1972.

M172 BODY MASS MEASUREMENT



SUBJECT IN POSITION FOR MEASUREMENT

E.I. 19D (Cont'd)



ALL DIMENSIONS IN INCHES

\*DIMENSION INCLUDES CALIBRATION  
MASS ADAPTER WHICH IS NOT SHOWN.

M172 Body Mass Measurement Device (Operational Configuration)

E.I. 25 CAGE, INVERTEBRATES.  
(E.U. 70 Invertebrate Holding Units.)

Purpose

To hold and support invertebrate colonies in controlled environments.

Requirements

Pressure of 14.7 psia

Single-pass air supply to avoid common use by several cages

Individual anesthetizing CO<sub>2</sub> lines

Mechanical attachment and plug-in system

Screened access port using penetrable elastic webbing to allow insertion and manipulation of a tube for removing or emplacing an anesthetized individual organism.

Hardware Status

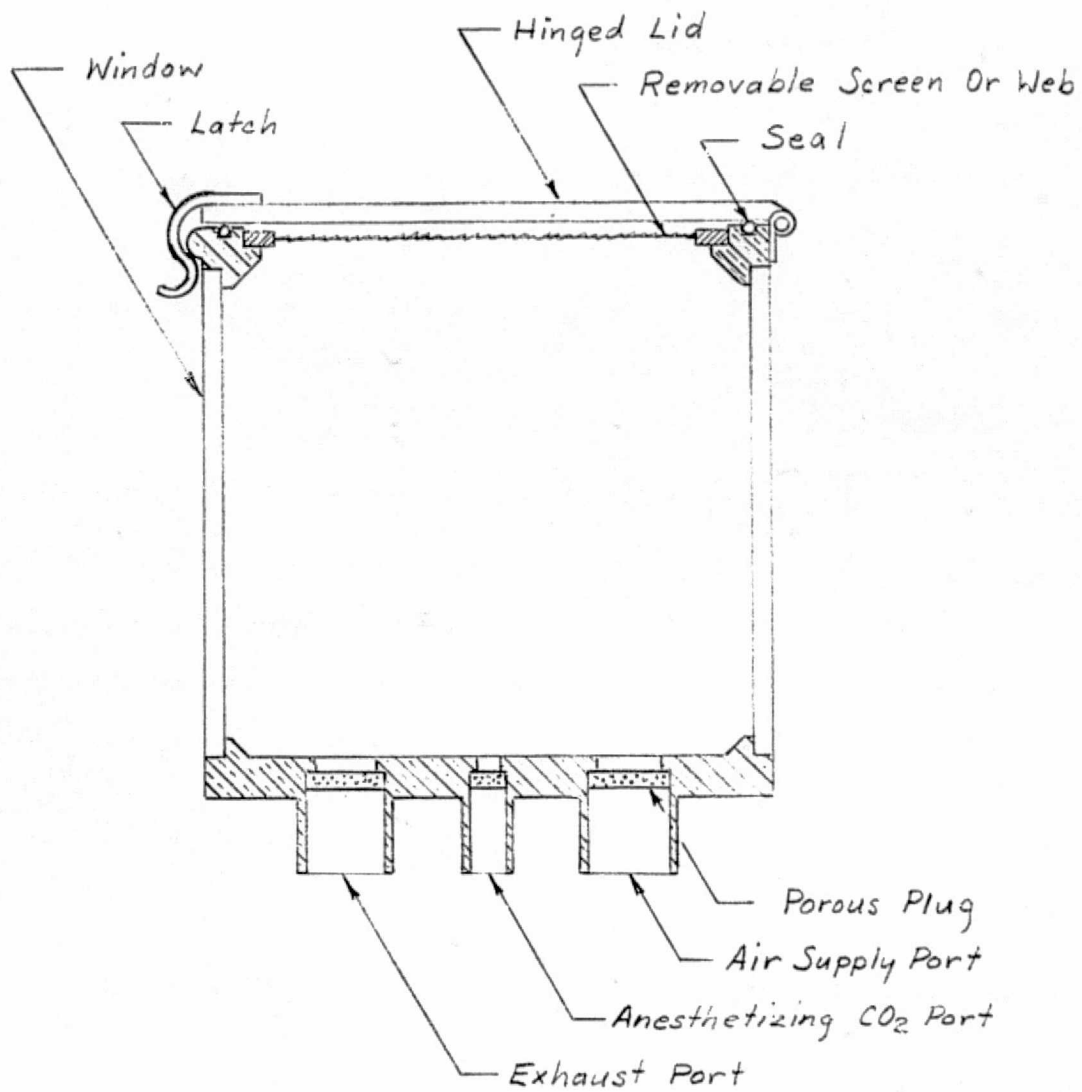
Rating: Re-Design

The cage is a conceptual design item incorporating existing laboratory techniques for anesthetizing and manipulating invertebrates.

Technical Description

Weight:	0.3 kg (0.7 lb)
Volume:	0.2 dm <sup>3</sup> (0.01 ft <sup>3</sup> ) (average size)
Power:	None

Development Time: 12 months



CASE, INVERTEBRATES

E.I. 25B COLONY CHAMBER, SEALABLE  
(E.U. 60, Cells/Tissues Holding Unit)

Purpose

To provide for culture growth in liquid media.

Requirements

TBD.

Hardware Status

Rating: Re-Design  
Conceptual design item.

Technical Description

A preliminary concept of this device utilizes petri dishes with membranes for separation of the liquid media from the oxygen environment needed for growth.

The estimated properties of this device are:

Weight:	0.2 kg (0.4 lb)
Volume:	0.1 dm <sup>3</sup> (0.004 ft <sup>3</sup> )
Power:	0

Development Time: 12 months

## E.I. 26A CAGE, METABOLIC, C/T

(E.U. 60 Cells/Tissues Holding Unit.)

### Purpose

This enclosure is to hold liquid broths in which cells and tissues are growing and to provide gas ports for sampling and measurement of carbon dioxide and oxygen exchange rates to determine growth rates.

### Requirements

1. Size: approx. 500 cc
2. Gas production rates: tbd
3. Liquid agitation required, but not in a manner which is damaging to the organisms.
4. O<sub>2</sub> and CO<sub>2</sub> measurements required

### Hardware Status

Rating: New Development

### Technical Description

Basis: Jar configuration with membrane for gas/liquid separation and batch gas analysis, see sketch.

E.I. 26A (Cont'd)

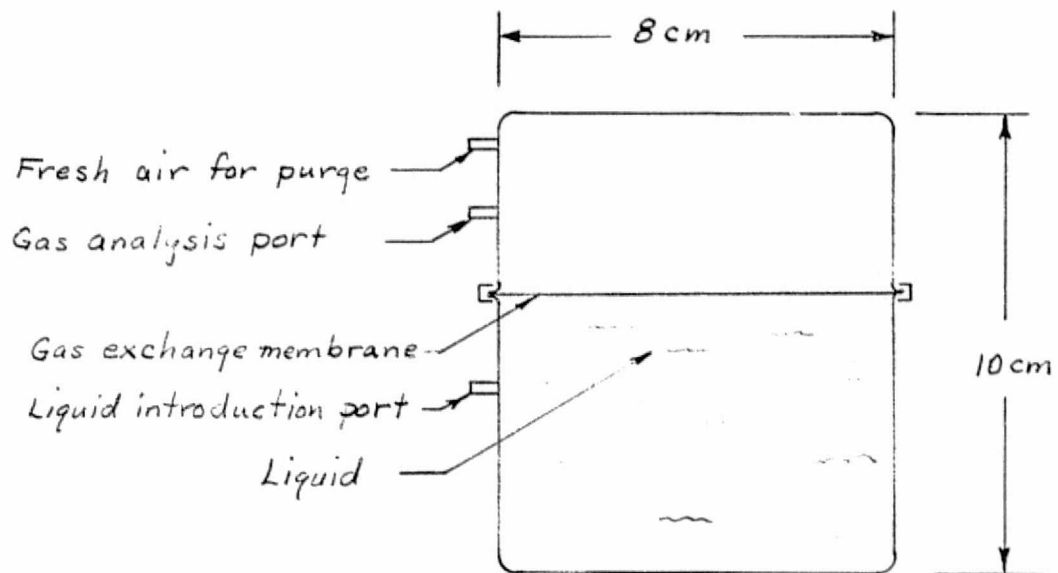
Wt.: 0.8 kg (1.8 lb) (liquid - 0.3 kg)

Size: Envelope approximately 10 cm dia. x 12 cm long (incl. agitation mechanism)  
(3.94" dia. x 4.72")

Volume:  $0.9 \text{ dm}^3$  ( $0.03 \text{ ft}^3$ )

Power: 5 watts

Development Time: 24 months.



## E.I. 26B CAGE, METABOLIC, PLANT

(E.U. 50 Plant Holding Unit.)

### Purpose

To allow plant  $O_2$  consumption to be determined during experiments of growth transients in roots exposed to weightless environment.

### Requirements

1. Sealed chamber.
2. Temperature, pressure, relative humidity, and  $pO_2$  sensors.
3. Noise and vibration isolation.
4. Light for photography.

### Hardware Status

Rating: Re-Design

This item may be developed in conjunction with the Plant Holding Unit (EI 101, EU 50). It will fit within the Plant Holding Unit.

### Technical Description (Estimate)

Weight:	7 kg (15.4 lb)
Envelope Dimensions:	8 cm diam., 6 cm high (20 in. diam., 15 in. high)
Envelope Volume:	76.6 dm <sup>3</sup> (2.6 ft <sup>3</sup> )
Power:	30 w

Development Time: 24 months.

## E.I. 28 CAGE, METABOLIC, RATS

(E.U. 40 Small Vertebrate Holding Unit.)

### Purpose

This cage houses a single rat and provides for measurements on its metabolic rate.

### Requirements

1. To measure the following approximate metabolic quantities for one rat:
  - a.  $O_2$  consumption: 12.6 dm<sup>3</sup>/day (0.45 ft<sup>3</sup>/day)
  - b.  $CO_2$  production: 10.71 dm<sup>3</sup>/day (0.38 ft<sup>3</sup>/day) (RQ = 0.85)
  - c. Urine output: 20 g/day (0.045 lb/day)
  - d. Water consumption: 50 g/day (0.11 lb/day)
  - e. Perspiration/Respiration: 38 g/day (0.082 lb/day)
  - f. Food consumption: 13 g/day (0.029 lb/day)
  - g. Fecal output: 3.2 g/day (0.007 lb/day)

### Hardware Status

Rating: SRT

The major problem is that of collecting and measuring urine and feces. This problem area may be studied as a part of the Holding Unit, Small Vertebrate development. Manufacturers of animal cages for metabolism studies include the following:

Acme Research Products  
5500 Muddy Creek Rd.  
Cincinnati, Ohio 45238

Kirschner Scientific  
1703 6th Ave. S.  
Seattle, Washington 98134

E.I. 28 (cont)

Labco  
3003 Lamb Ave.  
Columbus, Ohio 43219

Porter Matthews Scientific  
Route 1  
Princeton, New Jersey 08540

Technical Description

Estimated flight unit properties are:

Weight: 8 kg (17.6 lbs)  
Power: 20 watts  
Volume: 28.3 dm<sup>3</sup> (1 ft<sup>3</sup>)

Heat Rejection: 20 watts

Data Management: tbd

Location: Inside Holding Unit, Small Vertebrates (E.I. 103, E.U. 40)

Interfaces: Potential interfaces exist with: Holding Unit, Small Vertebrates, Gas Analyzer, Mass Spectrometer (E.I. 91, E.U. 5), Gas Analyzer (E.I. 93, E.U. 5), Atmospheric Sampling System (E.I. 15A, E.U. 5)

Development Time: 36 months.

## E.I. 29 CAGE, PLANT

(E.U. 50 Plant Holding Unit.)

### Purpose

To hold plants and seedlings.

### Requirements

Vented pots shielded from air impingement

Sealed pots (Lexan and/or glass) may be required.

Sizes from 200 cc to 12,000 cc including head room.

### Hardware Status

Rating: Redesign

### Technical Description

Estimated properties for 16 pots are:

Weight:	4.5 kg (10 lb)
Power:	0
Volume:	56.6 dm <sup>3</sup> (2 ft <sup>3</sup> )

Development Time: 12 months

E.I. 30A CAGE, RAT/HAMSTER, STANDARD  
(E.U. 40 Small Vertebrate Holding Unit.)

Purpose

To house single animals such as rats and hamsters in either a zero-g or 1-g environment.

Requirements

The rat was used as the basis for the sizing of the small vertebrate cages. The required inside dimensions of the cage are approximately 22.9 cm long  $\times$  15.2 cm wide  $\times$  14 cm high (9"  $\times$  6"  $\times$  5.5"). The cage should have at least one of its six sides transparent and one side openable. It should also incorporate an orientation screen, waste capture filter, feeding device, watering device, provisions for air circulation, and provisions for organism instrumentation interconnections.

Hardware Status

Rating: SRT

These cages should be developed as an integral part of the Holding Unit, Small Vertebrate (EI 103, EU 40).

Technical Description

A cage designed by General Dynamics Convair is shown in the attached picture. It was designed to fit into a holding unit which accommodates 8 such cages. This cage was used as a basis for the weight, volume and power estimates below.

Weight:	2.3 kg (5.1 lb)
Outside Dimensions:	33 cm long $\times$ 16.5 cm wide $\times$ 20.3 cm high (13" $\times$ 6 $\frac{1}{2}$ " $\times$ 8")
Outside Volume:	11 dm <sup>3</sup> (0.39 ft <sup>3</sup> )
Power:	9 watts (lights)

Development Time: 24 months in conjunction with the holding unit development.

E.I. 30A CAGE, SMALL VERTEBRATES (CONT.)

LAMINAR AIR VANES

SECURITY SCREEN

ECS AIR EXHAUST

WASTE/FEED DRAWER

AIR FLOW PLENUM

RAT CAGE

E.I. 31 CALCULATOR, POCKET  
(E.U. 2 - Data Management Unit)

Purpose

To facilitate experiment calculations and data reduction in the life sciences laboratory.

Requirements

Requirements are expected to include:

- Portability
- Battery or line operation with rechargeable batteries
- Scientific functions and exponential display mode
- Automatic round-off
- Addressable memory registers
- Programmable (may or may not be required)

Hardware Status

Rating: Repackage

The Hewlett Packard Model 65 is a high quality, fully programmable calculator which was used as the basis for the properties presented below. A similar but non-programmable model HP45 was tested by Beckman for its ability to withstand the spaceflight environment. Ref.: Analysis of Multipurpose Equipment for Space Application, Baumgartner, C.A., et al., Contract NAS8-29776, Beckmen Instruments, Inc., Advanced Technology Operations, Anaheim, CA, December 10, 1973.

Tests involved humidity, temperature, shock and vibration, electromagnetic interference (EMI), electrical power compatibility, out-gassing, and safety considerations. Beckman found that several problems existed but that "these problems are not serious and can easily be overcome by means of minor changes or careful handling". The following summary of problems and solutions was taken from the Beckman report.

PROBLEM	IMPLICATION/CRITICALITY	ACTION/SOLUTION
Normally hand-held	If not restrained, can float.	Use of a tether or velcro strap.
Radiated EMI	Inaccuracies in peripheral electronics & communications.	Do not use close to antennae of communications equipment.

### E.I. 31 CALCULATOR, POCKET (Cont)

PROBLEM	IMPLICATION/CRITICALITY	ACTION/SOLUTION
Susceptibility to radiated EMI	No susceptibility observed.	None.
Power Compatibility	Adapt existing recharger or develop a more compatible one, or operate only on battery.	Follow-on study to determine optimum course of action.
High humidity	Could cause shorts.	Use of conformal coating.
Battery recharger	Premature failure expected.	Use of replaceable batteries or intermittent use of recharger.

#### Technical Description

The properties of the HP 65 are:

Weight: Calculator & Batteries - 312 g (0.7 lb)  
 Battery Charger/Power Cord - 155 g (0.3 lb)  
 Total: 467 g (1 lb)

Dimensions: 15 × 8 × 3 cm (6 × 3 × 1 inch)

Volume: 0.4 dm<sup>3</sup> (0.01 ft<sup>3</sup>)

Power: Battery operated  
 Charger/power operation = 5 watts

Heat Rejection: 5 watts (maximum)

Data Management: None

Location & Interface: Do not use close to antennas or communications equipment due to EMI.

Development Time: 4 months.

E.I. 32 CAMERA, CINE  
(E.U. 1 Visual Records and Microscopy Unit.)

Purpose

To obtain motion picture records of various experiment events and phenomena.

Requirements

Specific requirements are yet to be determined. It is anticipated that a standard 16 mm camera with interchangeable lens would be adequate for use. Variable frame rates will probably be required, high frame rates (several hundred frames per second) for recording high speed physical phenomena and low frame rates (6/sec) for recording crew motions during crew/equipment interaction experiments. The Apollo cameras (described below) operate at 6 frames/second in order to minimize film weight. Standard commercial motion pictures are taken at 24 frames/second. Various accessories will be required such as camera mounts, lenses, lights, etc.

Hardware Status

Rating: Re-package

Maurer model 308 cameras were used on the Apollo and Skylab flights and are assumed to be available from NASA-JSC (Flight Crew Support Division). These cameras operated at 6 frames/second, but might be modified for operation at higher frame rates.

A commercially available Beaulieu R16B Automatic by Cinema Beaulieu Corp. offers variable frame rate and battery powered operation and may be usable. It is a 16 mm camera, with electric drive, through the lens viewing and exposure control, variable speed from 2-64 frames/sec., pulse mode with external control, and various film magazines available. It will accept a wide variety of "C" mount lens systems, has rechargeable battery and sound synchronization. It would require modifications to the battery charger to allow it to operate on 28 VDC. The camera weighs 3.2-3.7 kg (7-8 lb), occupies 8 dm<sup>3</sup> (0.3 ft<sup>3</sup>), and requires a maximum of 10 watts while charging its batteries.

Technical Description

A figure showing the Maurer model 308 data acquisition camera (DAC) with quick mount is shown on a subsequent page. This type of camera, including accessories, was assumed to be used in life sciences laboratories. Accessories might include a universal camera quick mount, several optional lenses, remote control assembly, a short power cable, a portable high intensity photographic lamp (EI 114E), light meter, optical ring sight, and film transport mechanism. The estimated total weight, power and volume of the equipment is:

E.I. 32 CAMERA, CINE (Cont'd)

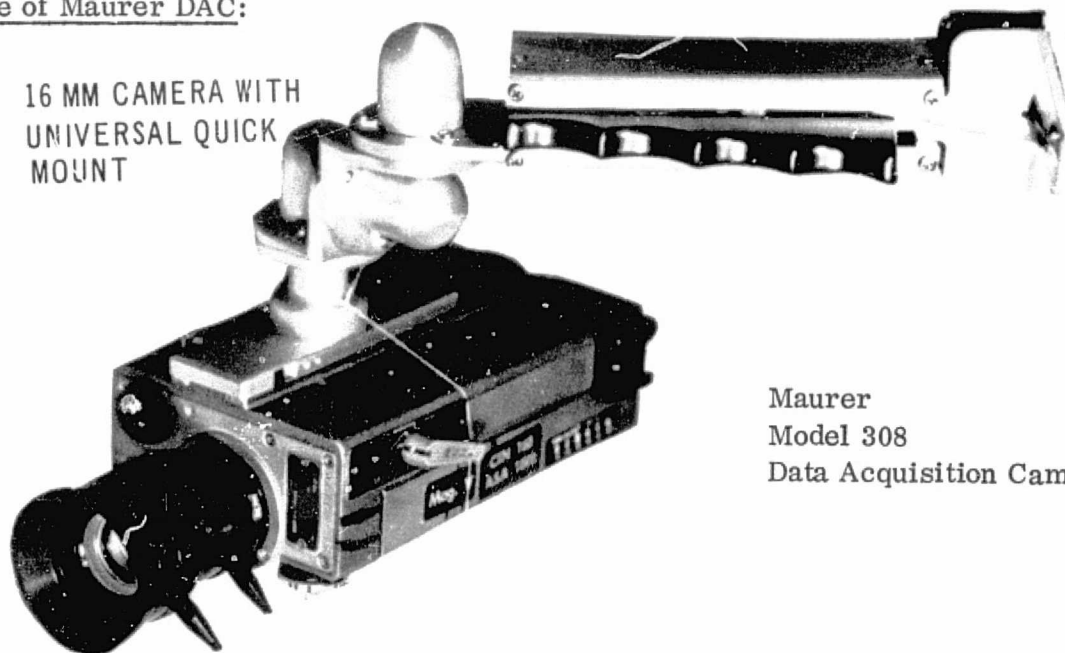
Weight	5 kg (11 lb)
Volume	5 dm <sup>3</sup> (0.18 ft <sup>3</sup> )
Power	12.6 watts, average (28 VDC)
	22.6 watts, peak

The film cassettes for this camera which were used on Skylab contained 400 ft of film which provided about 45 minutes of filming, See EI 75C, EU 1.

Development Time: 4 months.

Picture of Maurer DAC:

16 MM CAMERA WITH  
UNIVERSAL QUICK  
MOUNT

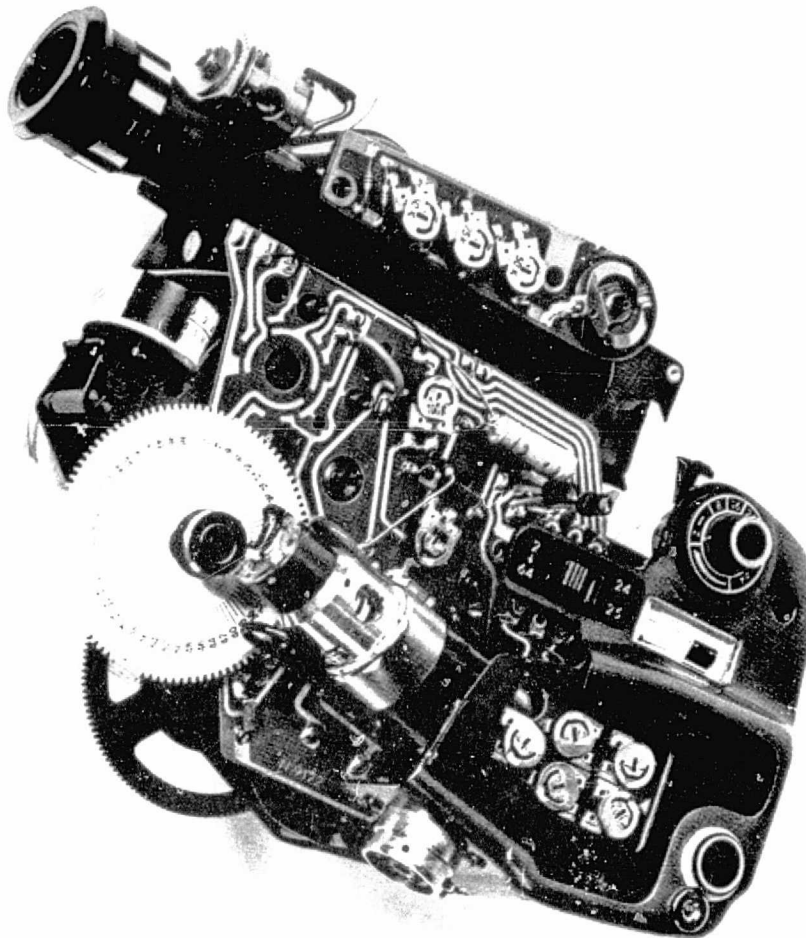


Maurer  
Model 308  
Data Acquisition Camera

*Basic principle of BEAULIEU electronic regulation*

*Should the motor's speed drop, the e.m.f. delivered by a dynamo coupled to the motor also drops; at this instant a transistorized amplifier delivers a higher current to the motor, thus enabling it to resume its selected speed.*

*Naturally, this feedback system acts in the opposite way should the motor's speed increase. This regulation control occurs within a few thousandths of a second—and acts continuously, thus ensuring completely even film transport.*



REPRODUCIBILITY OF THE  
ORIGINAL PAGE IS POOR

## E.I. 32A CAMERA CONTROLLER

(E.U. 1 - Visual Records and Microscopy Unit)

### Purpose

This is an electronic device used to control the operation of the video cameras throughout the laboratories.

### Requirements

The life sciences laboratories may contain multiple video cameras which monitor various organisms and research phenomena. Some of these cameras will operate automatically according to a predetermined data acquisition schedule. This device will issue commands to these cameras and process the data received. Processing will include tagging the data with time and identification, and transferring data to recording devices or monitors. Some of these cameras may operate in a time lapse mode of operation, taking a still picture of an organism every 10 seconds, for example. The data processing for this mode of operation may require the use of image storage devices with subsequent signal processing. The camera controller must operate in conjunction with the Spacelab CDMS, cameras, and associated electronic systems.

### Hardware Status

Rating: Redesign.

This equipment item must be designed and built. It is electronic in nature, and no new technology requirements are foreseen. Video image storage tubes may be required for use and those built by Princeton Electronics Products, Inc., North Brunswick, New Jersey (Phone 201/297-4448) were flown aboard the Mariner spacecraft.

### Technical Description

Estimated properties of the camera controller are:

Weight:	13.6 kg (30 lb)
Dimensions:	Can be configured to fit into Spacelab rack
Volume:	$28.3 \text{ dm}^3$ ( $1 \text{ ft}^3$ )
Power:	100 watts, 28 volt, d.c.
Heat Rejection:	100 watts

E. I. 32A (Cont'd)

Data Management: tbd

Location: Mount in Spacelab rack

Interfaces: CDMS, the black & white video cameras (E.I. 37, E. U. 1), and the color video cameras (E.I. 38, E. U. 1).

Development Time: 6 months

C 2

E.I. 33 CAMERA, POLAROID  
(E.U. 1 - Visual Records and Microscopy Unit)

Purpose

To provide photographic documentation of experiment events and phenomena which will be available for reference during the course of the mission.

Requirements

A Polaroid SX70 was assumed to meet the functional requirements of the life sciences laboratories.

Hardware Status

Rating: Space Qualified

A Polaroid SX70 was used on board Skylab (Stowage List Item No. 0122.01.00, Cat G-0S), and it was used as the basis for the descriptive data contained below.

Technical Description

The following weight and volume data for the Polaroid camera and accessories were obtained from Skylab data. The film (0.11 kg and  $11.2 \times 8.9 \times 1.3$  cm for 10 frames) is included in Film, Polaroid (E.I. 75F, E.U. 1).

Camera, SX70, Polaroid Assembly

Weight: 0.64 kg (1.41 lb)  
Size:  $10.2 \times 17.8 \times 2.5$  cm ( $4 \times 7 \times 1$  inches)  
Volume:  $0.45 \text{ dm}^3$  ( $0.016 \text{ ft}^3$ )  
Power: 0

Bracket, Polaroid Camera (including stowage bag)

Weight: 0.73 kg (1.61 lb)  
Size:  $7.6 \text{ cm} \times 20.3 \text{ cm dia.}$  ( $3 \times 8$  inches)  
Volume:  $2.46 \text{ dm}^3$  ( $0.087 \text{ ft}^3$ )

Scope, Persistent Image (including stowage bag)

Weight: 0.41 kg (0.90 lb)  
Size:  $15.2 \text{ cm} \times 5.1 \text{ cm dia.}$  ( $6 \times 2$  inches)

Miscellaneous accessory items including close-up lens, remote shutter button, and glare shield

Weight: 0.27 kg (0.6 lb)  
Volume:  $0.2 \text{ dm}^3$  ( $0.007 \text{ ft}^3$ ) estimated

E.I. 33 CAMERA, POLAROID (Cont'd)

Bag, Polaroid Equipment (for stowage of equipment above)

Weight: 1.24 kg (2.73 lb)

Total weight and volume for all of the above equipment in stowage bag was taken as:

Weight: 3.29 kg (7.25 lb)

Envelope Size:  $25 \times 15 \times 15$  cm ( $9.8 \times 5.9 \times 5.9$  inches) (estimated)

Envelope Volume:  $5.6 \text{ dm}^3$  ( $0.2 \text{ ft}^3$ ) (estimated)

Power: 0

Heat Rejection: 0

Location: It was assumed that the Polaroid camera would be stowed in one of the Spacelab stowage containers which provide approximately  $100 \text{ dm}^3$  of stowage volume each. Restraint attachments will have to be provided to be compatible with the stowage container.

Development Time: 4 months

References:

Skylab Stowage List, I-SL-002, NASA, August 31, 1973. For Information, Contact WC-5 (JSC), J. W. Thompson, 713/483-2483.

## E.I. 36 CAMERA, 35 MM AND STROBE

(E.U. 1 Visual Records and Microscopy Unit.)

### Purpose

To document visual experiment events and phenomena including microscopic images.

### Requirements

Requirements have not been defined but probably would be satisfied by a high quality commercial camera. The requirements for attachments and auxilliary lenses will depend upon the specific experiments.

### Hardware Status

Rating: Space Qualified

Existing commercial cameras are probably suitable. A Nikon camera with a F/1.2 lens was included in the Skylab equipment and was used as a basis for the properties listed below.

### Technical Description

Estimated properties of the 35 mm camera with film and accessories such as flash attachment and auxilliary lenses are:

Weight:	2.0 kg (4.4 lb)
Envelope Volume:	2.0 (0.07 ft <sup>3</sup> )
Power:	0

Development Time: 4 months

## E.I. 37 CAMERA, VIDEO, BLACK/WHITE

(E.U. 1 Visual Records and Microscopy Unit.)

### Purpose

To monitor experiment events and phenomena.

### Requirements

Estimated requirements are:

Visual Response	Approximate human eye
Video Output	Constant with light level changes of 10-10,000 ft-candles 1.4 V. P-P composite, conforms to EIA RS-170 standard

### Hardware Status

Rating: Space Qualified

Commercially available black and white TV cameras should be usable. One such camera is the Model ED 6038A TV Instrumentation Camera, by General Electrodynamics Corp. This unit is space vehicle qualified and operates from 28 VDC. It is described in the attached catalog sheets. Another potentially usable camera is the Cohn 2000 Series miniaturized TV camera. Several catalog sheets are also included for this camera series.

### Technical Description

The Electrodynamics camera was used as the basis of the following data.

Camera:	Weight	0.54 kg (1.2 lb)
	Size	3.8 cm Dia. × 15.2 cm L. (1.5" Dia., 6" L.)
	Volume	172 cc (.006 ft <sup>3</sup> )
Control Unit:	Weight	3.86 kg (8.5 lb)
	Size	12.2 cm H. × 16.5 cm W. × 14 cm D. (4.8" H., 6.5" W., 5.5" D.)
	Volume	2.82 dm <sup>3</sup> (0.1 ft <sup>3</sup> )
	Power	15 w, 28 VDC

Development Time: 6 months.

## MINIATURE

Three actual size photographs on succeeding pages tell how small the camera really is. What they cannot tell is that the ED 6038 A camera head weighs only 14 ounces and the ED 6038 A-1 camera head weight is 48 ounces. The control unit has a depth of 6½ inches and weighs 8¼ pounds.

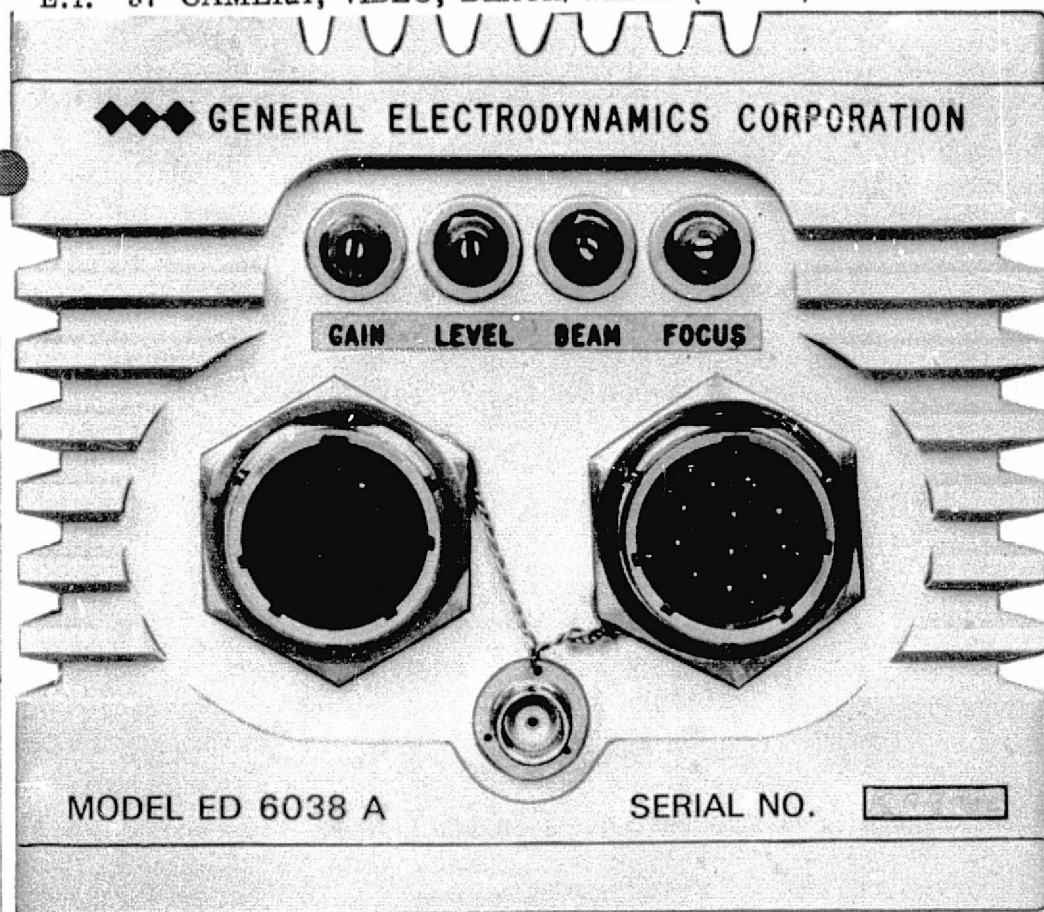
## RUGGED

Look at the environment in which this camera will operate:

Vibration	20 cps — 2 kc random distribution 20 G's RMS in each of three axes 60 G's RMS for three seconds, in each of three axes
Shock	100 G's for 11 ms
Temperature	-10°C to +71°C, Operating
Relative Humidity	100%
Explosive atmosphere	
Ambient acoustical noise	More than 175 db overall sound pressure level
Altitude	Space Environment

## VERSATILE

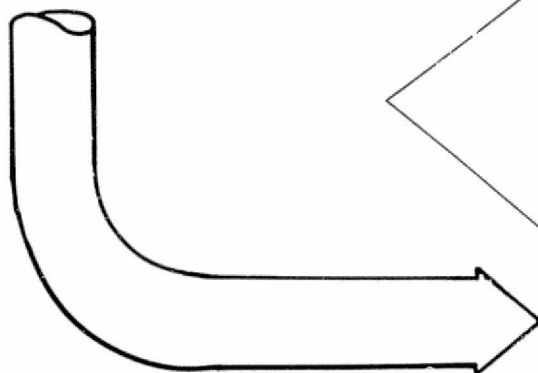
General Electrodynamics Corporation's total electro-optical capability enables it to quickly engineer most application requirements where instrumentation television is indicated. Our Electronic Tube Division supplies the "eye" for this camera. All you have to tell us is what the "eye" must see.



(ACTUAL SIZE)

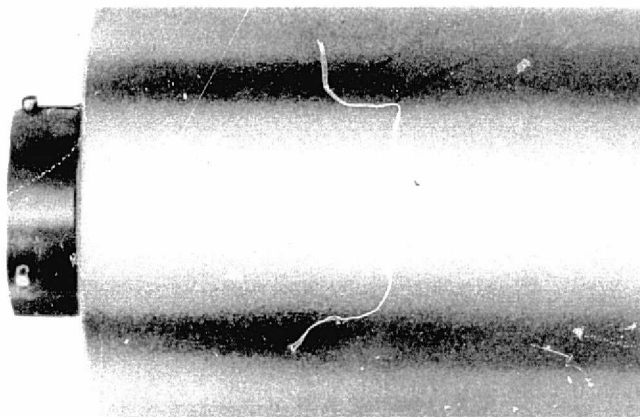


UP  
TO  
150  
feet

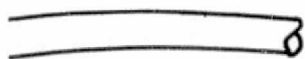


COMPLETELY  
INTERCHANGEABLE  
ONLY NECESSITATES SWEEP  
ADJUSTMENT IN CONTROL BOX

ED 6038 A-1 USI



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24 to 36 V.D.C.  
15 watts

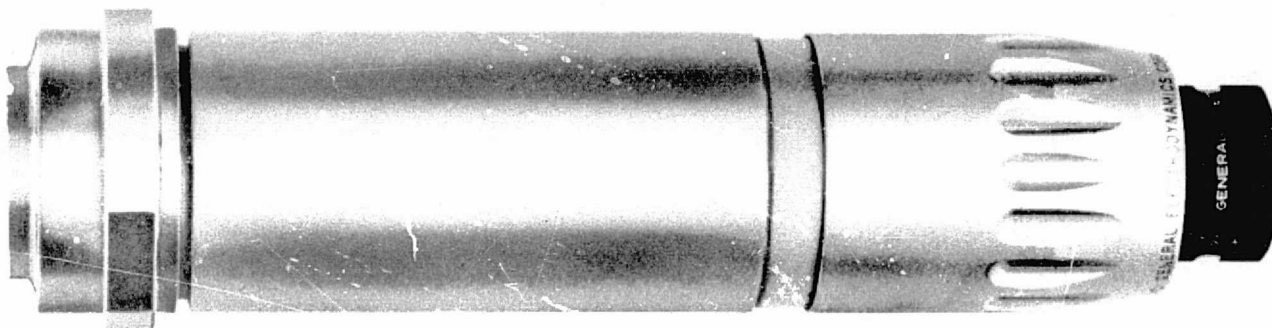


COMPOSITE VIDEO SIGNAL  
CONFORMS TO EIA  
STANDARD RS-170

1500 feet  
G-59  
LINE AMPLIFIERS

7

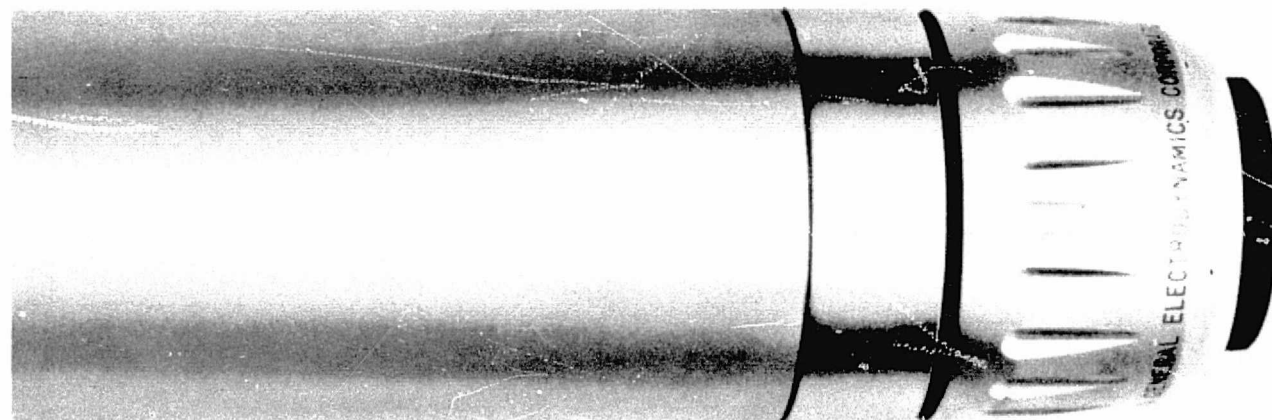
ED 6038 A USES 1/2-INCH TD 1305 VIDICON 500 TV LINES RESOLUTION



(ACTUAL SIZE)

"D"  
MOUNT  
LENS

IS 1-INCH TD1339 VIDICON 700 TV LINES RESOLUTION



"C"  
MOUNT  
LENS

(ACTUAL SIZE)

# E.I. 37 CAMERA, VIDEO, BLACK/WHITE (CONT.)

## FEATURES

Electrostatic Focus Vidicon Tube  
Sampling of yoke currents  
assures vidicon protection  
from sweep failure.  
Plug-in printed circuits  
Solid state system  
Reliable, detailed pictures under  
adverse environmental conditions.

## ACCESSORIES

### LENSES

5.5 mm	f/1.8	(GEC 1499)
10 mm	f/1.8	(GEC 2035)
25 mm	f/1.4	(GEC 2036)
38 mm	f/2.8	(GEC 2037)
75 mm	f/4.2	(GEC 2038)

HEAD MOUNT MODEL MD 380

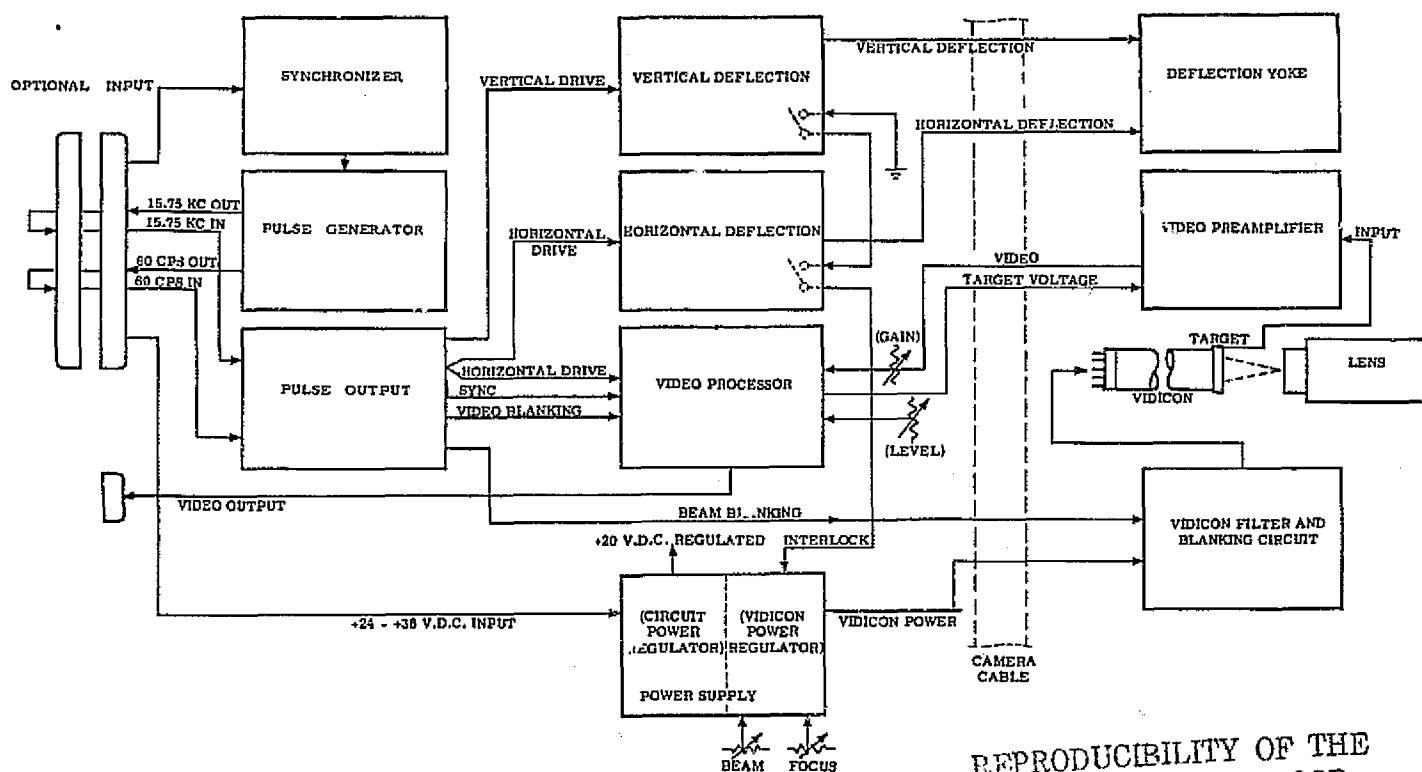
## SPECIFICATIONS

Horizontal Scanning Frequency.....15,750 cps  
Vertical Scanning Frequency.....60 cps  
Interlace.....2:1 30 fr/sec  
Aspect Ratio, Height to Width.....3:4  
Sweep Linearity.....Better than  $\pm 1\%$   
Sync and Blanking.....Standard Broadcast EIA

Video Output.....1.4 V PP composite into 75-ohm load  
Automatic Constant Video Output ..10—10,000 ft. candle  
Usable Pictures.....obtained with 1 ft. candle  
Color Response.....Approximates human eye  
Grey Scale Reproduction.....10 steps  
Keyed Clamp.....Provides constant black level

Voltage Regulation holds picture stable over 24 to 36 VDC  
Input Power.....24 to 36 VDC, 15 watts

## BLOCK DIAGRAM



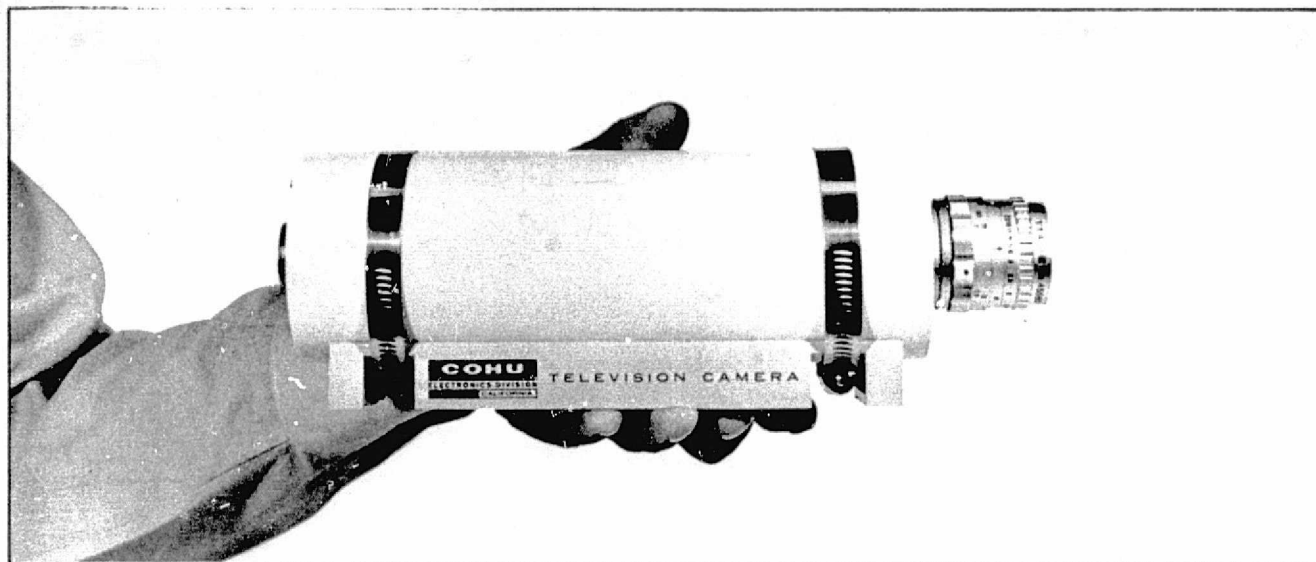
2-73

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# 2000 SERIES

## COHU

### Miniaturized TELEVISION CAMERAS



### Features

Miniaturized Integral Zoom Lens and Lens-Drive Accessories

3" Outside Diameter Standard Housing

Operates From -17 to +60 C . . . in High Altitudes . . . High Humidity . . . Explosive Environments

Circuits all Solid-State

Full 850-Line Horizontal Resolution

10 or 20 MHz Bandwidth

Vidicon Protective Circuit

Designed for Continuous Duty Operation

### Description

The Cohu 2000 Series of miniaturized television cameras is suitable for continuous-duty televising from either fixed or moving camera positions. Operation is possible within a wide environmental range and under conditions where weight and space are prime considerations. Extremes of temperature, humidity, dynamic pressure, altitude, noise, vibration, shock, or acceleration will not, within broad limits, affect camera operation.

The 2 3/4" diameter camera electrical assembly is mounted in a sturdy framework which is inserted into a cylindrical housing and positioned by the rear end plate which is part of the framework. With the exception of the vidicon, camera electrical components are all solid-state. The standard housings, which have an outside diameter of 3", are machined of highly corrosion-resistant aluminum alloy and finished with a heat-

You expect more from



. . . and you get it.

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**Description** continued

reflecting weather-resistant white baked enamel. Housing length is determined by lens requirements. In totally enclosed models a nonreflecting protective faceplate of optical glass is bezel-sealed at the front of the housing and a sealed bulkhead multiconnector is mounted at the rear. Exposed-optics models accept externally mounted lenses and are available in either sealed or unsealed housings.

A model with a built-in 10:1 (15mm-150mm) f/2.8 remotely controlled zoom lens is available. The lens is accommodated by adding an 8.7" long, 4" outside diameter extension to the basic 3" outside diameter camera barrel. The 2000 Series Cameras are also available with enclosed fixed focal-length lenses, or with an exposed "C" mount which accepts standard 16mm lenses. Cohu lens data sheets contain detailed performance specifications.

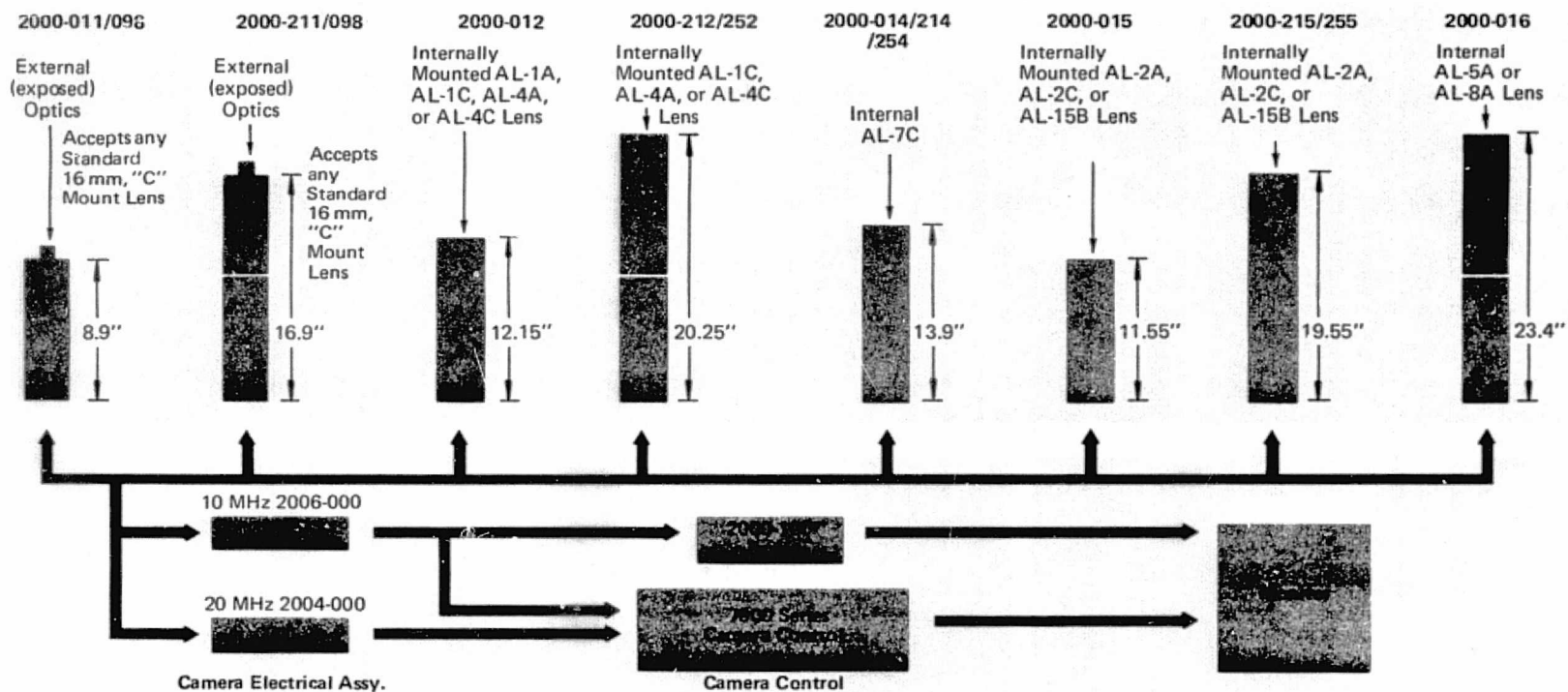
Camera circuitry includes a video preamplifier to increase vidicon output and match camera output impedance to the coaxial cable. Other circuits provide a constant filament and focus coil current and linear horizontal deflection. A protective circuit prevents damage to the vidicon target in the event of sweep-signal or cable failure.

Control of 2000 Series Cameras is provided by any of several types of Cohu camera controls. The 7900 Series camera controls operate on 117V ac 60 Hz with a 230V ac model available on special order. The 7900 Series includes single and dual rackmount and portable versions. Line rates available are 525, 729, 873, or 945. A 2000-100 Model Camera Control Unit is an integral assembly on the 2006-200 Model Cameras. The 2000-100 Control Unit can also be attached to the rear of other 2006 Model Cameras to form a single unit. The unit operates on 22 to 30V dc and has a 525-line rate.

Cameras with 10 MHz bandwidths function to EIA standards at the broadcast sweep-scan rate provided by a camera control equipped with a 525-line synchronizing generator. Use of an optional 729-line sync generator in the camera control provides a square resolution picture (refer to Specifications). Other optional camera controls furnish 873-line and 945-line rasters for 20 MHz cameras to provide extremely high-resolution picture details.

The small, lightweight cameras of the 2000 Series cover a wide range of mechanical configurations to satisfy optical demands of virtually any application. Picture quality of the 2000 system meets the exacting requirements of the precision sciences, such as TV microscopy. Environment resistance of 2000 Series Cameras allows them to be mounted permanently in the exposed installations of all-weather equipment, such as used in radar boresighting; these compact cameras add a minimum of weight to the radar antenna. 2000 Series Cameras also resist the hazardous environments encountered in rocket testing and launching, where explosion-proof requirements are stringent and shock resistance is critical; in the radiation fields of a nuclear reactor; or in applications where processes involving toxic, flammable, or corrosive chemical liquids or vapors must be observed from a safe distance. The standard 2000 Series housing moves freely within the three-inch pipe casings used in oil drilling; casing inspection by television saves hours of costly down-time and averts damage to equipment. The use of waterproof cable and connectors allows 2000 Series Cameras to operate underwater without the excess bulk of additional waterproof enclosures. The compact cylindrical structure of these cameras is more resistant to pressure than larger units of similar or other design. 2000 Series Cameras are compatible with all external accessories of Cohu's larger environment-resistant cameras, and are directly interchangeable for installations where 2000 Series specifications are applicable.

## Planning Diagram



\*2000-100 Camera Control contains integral 525-line sync generator; other controls accept 525-line, 729-line, 873-line, or 945-line sync plug-in adapter boards.

## MODEL NUMBERS FOR CAMERAS WITHOUT VIDICONS (See Cohu Lens Data Sheets for lens specifications)

Camera w/o Control Unit		Camera w/Integral Series 100 CCU		Lens				Shipping Wt. in Pounds				LENS DESCRIPTION
20 MHz	10 MHz	10 MHz Only										
Aluminum Barrel		Aluminum Barrel	Stainless Steel Barrel									
2004-005	2006-005	2006-205		10:1 Zoom Lens	17	17	18				10:1 Zoom- f/2.8, 15-150mm, 48°-4.8° HVA	
2004-006	2006-006	2006-206		10:1 Zoom Lens w/1.5XA Ext	18	18	19				10:1 Zoom/1.5XA Extender - f/3.8, 22.5-225mm, 30°-3° HVA	
2004-007	2006-007	2006-207		10:1 Zoom Lens w/2XA Ext	18	18	19				10:1 Zoom/2XA Extender - f/5.6, 30-300mm, 23°-2.3° HVA	
2004-011	2006-011	2006-211		Enclosure, Exposed Lens Type	11	11	19				AL-1A - ½", f/1.4, 53° HVA	
2004-098	2006-098	2006-298		Sealed Enclosure, Exposed Lens Type	11	11	19				AL-1C - ½", f/1.5, 53° HVA	
2004-012	2006-012	2006-212	2006-252	AL-1A, -1C, -4C, -4A, -14C	9	10	20	21			AL-2A - 1", f/1.4, 28° HVA	
2004-014	2006-014	2006-214	2006-254	AL-7C	9	10	20	22			AL-2C - 1", f/1.4, 28° HVA	
2004-015	2006-015	2006-215	2006-255	AL-2A, -2C, -15B	9	10	20	22			AL-4A - 2", f/1.4, 19° HVA	
2004-016	2006-016			AL-5A, -8A	9	10					AL-4C - 2", f/1.4, 19° HVA	
											AL-5A - 3", f/1.4, 9.6° HVA	
											AL-7C - 4", f/2.8, 7.1° HVA	
											AL-8A - 6", f/2.8, 4.8° HVA	
											AL-14C - 10mm, f/1.9, 70° HVA	
											AL-15B - 1", f/0.95, 28° HVA	

## Model Information

## Specifications

Camera specifications may be limited by the characteristics of the various types of vidicon tubes used. These may be specified for use in a camera to obtain maximum picture quality under the environmental conditions of the specific installation.

### ELECTRICAL (Measured at 25 C)

Camera Model	2006		2004	
Overall System Bandwidth	10 MHz		20 MHz	
Vidicon	7262A or 7263A ruggedized		8573A	
Scanning Pattern (for all systems, 2:1 interlace; vertical field frequency 60 Hz; vertical frame frequency 30 Hz; horizontal frequency as shown)	525-line 15,750 Hz	729-line 21,870 Hz	873-line 26,190 Hz	945-line 28,350 Hz
Horizontal Resolution (at center of picture) (at all four corners)	700 lines 400 lines	550 lines 400 lines	850 lines 650 lines	800 lines 650 lines
Vertical Resolution (at center of picture)	350 lines	500 lines	600 lines	650 lines

Linearity & Distortion	Combined geometric distortion and scan nonlinearity within 3%, measured in accordance with EIA Specification RS-330/RS-343 for 729-, 873-, and 945-line and RS-170 for 525-line
Sensitivity	Produces usable picture with 0.1 foot-candle of illumination on the vidicon faceplate. Meets stated resolution specifications and resolves all ten shades of gray on EIA TV Resolution Chart with 1.0 foot-candle (2854°K) highlight illumination on the vidicon faceplate
Vidicon Protection	All solid-state circuits protect vidicon in event of sweep or cable failure
RF Noise Suppression	Built-in filter circuits
Power Requirements	All power supplied through camera control cable by camera control unit

### ENVIRONMENTAL\*

Ambient Temperature Limits	Operating -17 to +60 C (0 to +140 F) without auxiliary heating or cooling; storage, to MIL-E-5400M, para. 3.2.24.1 (Class 1) -65 to +85 C (-85 to +185 F)
Vibration Limits	MIL-E-5400M, para. 3.2.24.5, Curve 1V 10 g, 5 Hz to 500 Hz
Shock Limits	MIL-E-5400M, para. 3.2.24.6 (15 g's on each axis)
Humidity Limits	MIL-E-5400M, para. 3.2.24.4 (sealed up to 100%)
Sand and Dust	MIL-E-5400M, para. 3.2.24.7
Fungus	MIL-E-5400M, para. 3.2.24.8
Salt Atmosphere	MIL-E-5400M, para. 3.2.24.9
Acoustic Noise	Operates in very high acoustic noise environment such as close to hi-thrust rocket engines

\*Some environmental specifications may vary for unsealed/exposed optics camera models.

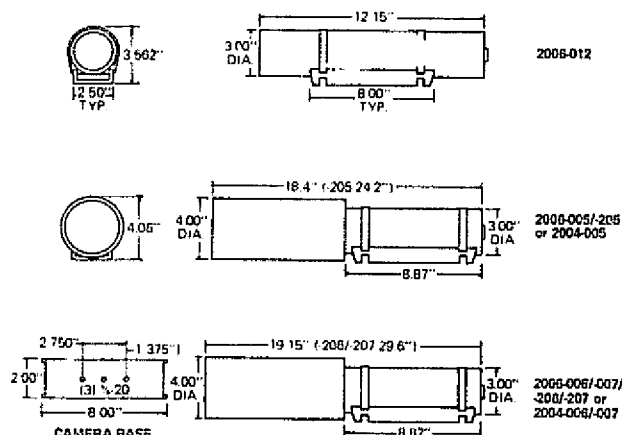
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Magnetic Shielding	Vidicon assembly shielded by Mu-metal magnetic shield
Altitude	Out to deep space
Explosion	Meets MIL-E-5272C, Procedure IV, para. 4.13.5., and MIL-STD-810, Procedure II, Method 511
Underwater	250 feet in depth with factory installed waterproof cable connections; greater depths with accessory housings

### MECHANICAL

Lens Mount	Will accept standard 16 mm "C" mount lenses
Camera Housing	High-strength tubular construction; optical glass faceplate in all housing models except 2000-011/-098
Camera Mounting	Three ¼"-20 mounting sockets in camera base
Camera Cable	A selection of camera cable with MIL standard connectors is available. Full resolution provided with up to 2000 feet of AC-24 cable for 10 MHz systems and 500 feet with 20 MHz systems
Cable Connection	Bulkhead multiconnector mounted on rear end plate of camera housing. MIL standard types available. All internal accessories and camera functions are energized through this connector via the camera control cable
Circuit Construction	All electronic components mounted on glass-epoxy circuit boards. All solid-state except vidicon tube
Dimensions	See Planning Diagram and Dimensional Diagram
Weight	See Model Numbers for Complete Cameras in Table on previous page

### Dimensional Diagram



Cohu reserves the right to change specifications without notice.

E.I. 38 CAMERA, VIDEO COLOR  
(E. U. 1 - Visual Records and Microscopy)

Purpose

This camera is primarily used for visual color documentation which must be transmitted to ground during the progress of the experiments. It is expected that such transmission to ground will not be required for all experiments. Thus, the color video camera is a potential candidate for elimination from some laboratories. Visual color documentation which does not have to be transmitted to ground can be obtained with the still or motion picture cameras.

Requirements

Detailed requirements have yet to be determined. Some of the most stringent requirements anticipated have to do with the reproduction of specimens under microscopic examination. Documentation of MSI activities are required but should not pose any special problems.

Hardware Status

Rating: New Development.

Color video cameras have been used aboard many of the past space flights. However, these cameras may not have adequate resolution for microscopy work. The development of an advanced color video camera is currently being initiated by NASA for use in the Shuttle Orbiter.

Technical Description

Estimated properties of the color video camera and controller are:

Weight:	7.7 kg (17 lb)
Dimensions:	Camera, 12.7 cm H $\times$ 7.6 cm W $\times$ 22.9 cm D (5 $\times$ 3 $\times$ 9 inches) Controller: tbd
Volume:	6.21 dm <sup>3</sup> (.22 ft <sup>3</sup> )
Power:	69 watts, 28 v., d.c.
Heat Rejection:	69 watts

E.I. 38 (Cont'd)

Data Management: Video signals must be handled by the CDMS. The number and scheduling of camera operations will depend upon experiments.

Location: Store in Spacelab storage compartment. Portable for use with various E.I.s.

Interfaces: Camera should be compatible with various E.I. mounting provisions such as for the Compound Microscope (E.I. 126, E.U. 1), the Dissecting Microscope (E.I. 126A, E.U. 4), the Work & Surgical Bench (E.I. 188, E.U. 4), and the holding units.

Operations: Needs to be fitted for easy mounting, removal, and transfer around the laboratory. Several plug-in points may be necessary.

Development Time: 6 months.

E.I. 38B CAMERA MOUNTS  
(E.U. 1, Visual Records and Microscopy Unit)

Purpose

To provide structural support for the placement of the video and 35 mm cameras.

Requirements

The camera mounts should be portable so that they can be used in several pre-determined locations within the Spacelab. In addition, the mounts should provide an adjustable head for proper aiming and positioning of the camera during operation.

Hardware Status

Rating: Modification.

Modified versions of various commercial mounts will meet all the requirements for the Spacelab.

Technical Description

Estimated values are:

Weight	3 kg (6.6 lb)
Volume	3 dm <sup>3</sup> (.1 ft <sup>3</sup> )
Power	0

Development Time: 12 months.

## E.I. 38D CAMERA TIMER, VIDEO

(E.U. 1 - Visual Records and Microscopy Unit)

### Purpose

To provide on-off control for the operation of video cameras used to monitor MSI performance experiments.

### Requirements

Required is a prescheduled time controlled switching device to control the video camera and the video tape recorder. This will be used for documentation of specific MSI experiments or general crew activity.

### Hardware Status

Rating: Modification.

A Sony Corporation video camera selector VCS-31 which provides camera on-off and switching capability could be modified to provide the desired controller. This modification would require the incorporation of a timing device that could be set manually to provide continuous or intermittent operation of the camera/recorder unit.

### Technical Description

The estimated flight characteristics are:

Weight	4 kg (8.8 lb)
Size	25 × 8 × 15 cm (10 × 3 × 6 in.)
Volume	3 dm <sup>3</sup> (0.11 ft <sup>3</sup> )
Power	10 watts

Development Time: 9 months.

## E. I. 38F CARDIOPULMONARY ANALYZER

(E. U. 31 Biomedical/Behavioral Research Support Unit)

### Purpose

This device is capable of performing a battery of eight cardiopulmonary tests by recording flow, volume, and partial pressures of a human subject.

### Requirements

Gas Supply: Six 975 liter capacity high pressure bottles.

Calibrated Volume Dispensing: From four to 30 liters of a selected gas can be dispensed into the breathing bag with a precision of 1%.

Breathing Flow and Volume: Respiratory flow and volume will be measured with an overall accuracy of 1%.

Range of Flow Measurement: 0 to 10 liter/second.

Volume Resolution on Closing Volume Test: 3 cc.

Monitored Gases:  $H_2O$ ,  $N_2$ ,  $C^{18}O$ ,  $O_2$ , A,  $CO_2$ ,  $N_2O$ .

Monitored Mass Numbers: 18, 28, 30, 32, 40, 44

Partial Pressure Range:  $N_2 = 100\%$ ,  $O_2 = 100\%$ ,  $C^{18}O = 1\%$ ,  $N_2O = 2\%$ , others = 10%.

Stability: Less than 1% change in full scale deflection in 15 minutes after warmup. Automatic rezero for  $C^{18}O$  pressure.

Response Time: 100 ms for 90% response on flow, volume, and all partial pressures except  $C^{18}O$ . One second for  $C^{18}O$ .

### Hardware Status

Rating: SRT.

A prototype unit is being developed by Perkin-Elmer and will be flight-tested in a zero-g aircraft in 1975. This unit replaces the Metabolic Analyzer aboard Skylab and expands the capability of the prior unit to include measurements and determinations of breath-by-breath  $O_2$  uptake,  $CO_2$  output, tidal volume, minute volume, respiratory exchange ratio, partial pressures, vital capacity, closing volume, total lung capacity, pulmonary capillary blood flow, residual lung volume among others.

### Technical Description

The Cardiopulmonary Analyzer consists of gas supply bottles for calibration and test, a respiratory module for flow measurement, valving and subject interface, a modified Skylab mass spectrometer for the analysis, and a data acquisition system.

## E.I. 38F CARDIOPULMONARY ANALYZER (cont.)

The properties for the prototype unit are:

Weight:	169 kg (373 lb.)
Envelope Dimensions:	68.5 cm H 90.0 cm W 68.5 cm D (27 H x 35.5 W x 27 D, in.)
Envelope Volume:	422 dm <sup>3</sup> (14.9 ft <sup>3</sup> )
Power:	60 Hz 115 VAC 200 VA
	400 Hz 115 VAC 230 VA
	28 VDC 140 watts

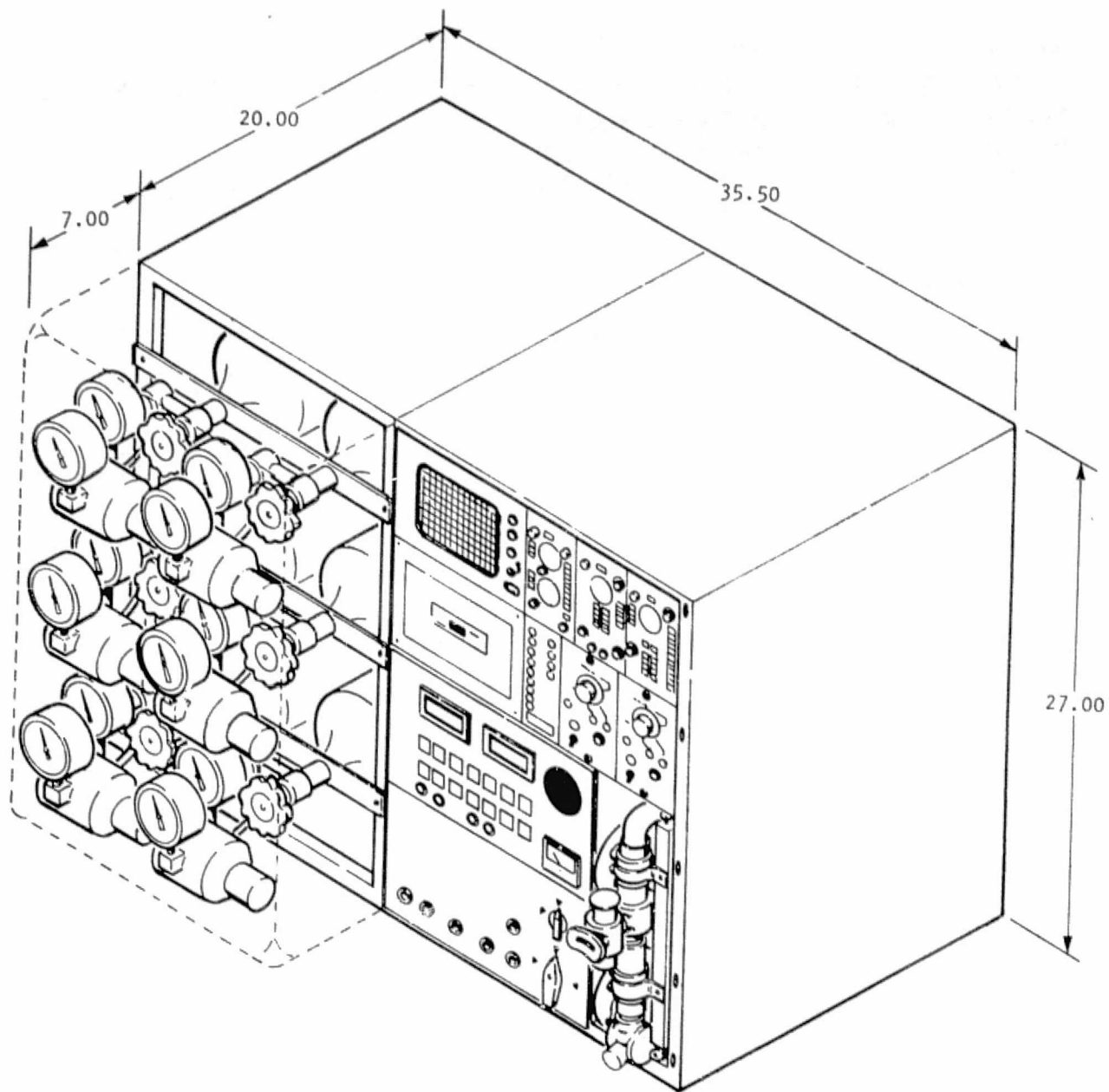
Estimated properties of the flight unit are:

Weight:	90.7 kg (200 lb.)
Volume:	172 dm <sup>3</sup> (6.0 ft <sup>3</sup> )
Power:	200 watts

Development Time: 24 months

### Reference:

Fabrication of a Prototype Cardiopulmonary Analyzer, Contract No. NAS2-6494, Perkin-Elmer Corp., Aero-Space Division, September 1974.



Prototype Cardiopulmonary Analyzer System

E.I. 40A CENTRIFUGE, BLOOD SAMPLE PROCESSOR  
(E.S. 4 Preparation and Preservation Unit.)

Purpose

Centrifugation of human and vertebrate blood samples.

Requirements

The requirements of this item are similar to those of the existing centrifuge used on Skylab which centrifuges human blood samples of about 10 cc contained in special "blood sample processor" syringes. However, the life sciences centrifuge must be capable of centrifuging smaller blood samples of 0.1 to 1 cc from humans and small vertebrate organisms.

Hardware Status

Rating: Modification

This item is space qualified, but some modifications will be required. This will include a head modification for the purpose of accepting smaller samples.

Technical Description

The properties of the Skylab unit were used for life sciences laboratory conceptual design purposes. Its properties are:

Weight	12.7 kg (28 lb)
Head Diameter	3.3 dm (13 inches)
Power	100 w (peak, 28 volt d.c.)
Volume	25 dm <sup>3</sup> (0.88 ft <sup>3</sup> ), estimate
Speed	2600 rpm or 3000 rpm

Development Time: 9 months

E.I. 43A CENTRIFUGE, BIORESEARCH  
(E.U. 23 - Internal Centrifuge Unit)

Purpose

To provide a controllable artificial gravity environment for biological organisms.

Requirements

Preliminary design guidelines for the Bioresearch Centrifuge are:

1. Assume centrifuge is located at rear end of Spacelab with axis of rotation along centerline of Spacelab.
2. Centrifuge must accommodate 16 rats or their approximate equivalent in other organisms weighing between 0.2 - 1.0 kg.
3. Organisms are located at a minimum radius of 137 cm (4.5 ft) to reduce g-gradient effects.
4. The basic g requirement is for a constant 1-g level maintained throughout mission. However, capability for 0.1 to 3.0 g should exist by altering the angular speed.
5. Rotation is initiated after Shuttle launch and injection and terminated prior to reentry.
6. An open EC/LSS is assumed with the exception that effluents will be filtered and treated before return to the Spacelab environment.
7. Start-up and stop times can be on the order of minutes.
8. Assume that Bioresearch Centrifuge is stopped once/day for organism removal or loading, food and water resupply, waste collection, etc.

There are two guidelines (Nos. 6 and 8) that impact the complexity and hence the cost of the centrifuge. An open EC/LSS simplifies the design considerably. Air is passively drawn from the cabin environment with scoops and radially forced through the cages, large particle filters and returned to the cabin. A blower is used when the motion is stopped. A closed system, on the other hand, requires ducting, blowers, filters, and substantially increases the complexity.

## E.I. 43A BIORESEARCH CENTRIFUGE (Cont'd)

It may be desirable to have the centrifuge continuously rotate for the entire mission duration (up to 30 days) so as not to perturbate the control environment that the centrifuge is seeking to establish. In this case, the problem of man-interaction with the centrifuge for specimen loading or removal, consumables resupply, waste management, etc., becomes important.

### Hardware Status

Rating: SRT.

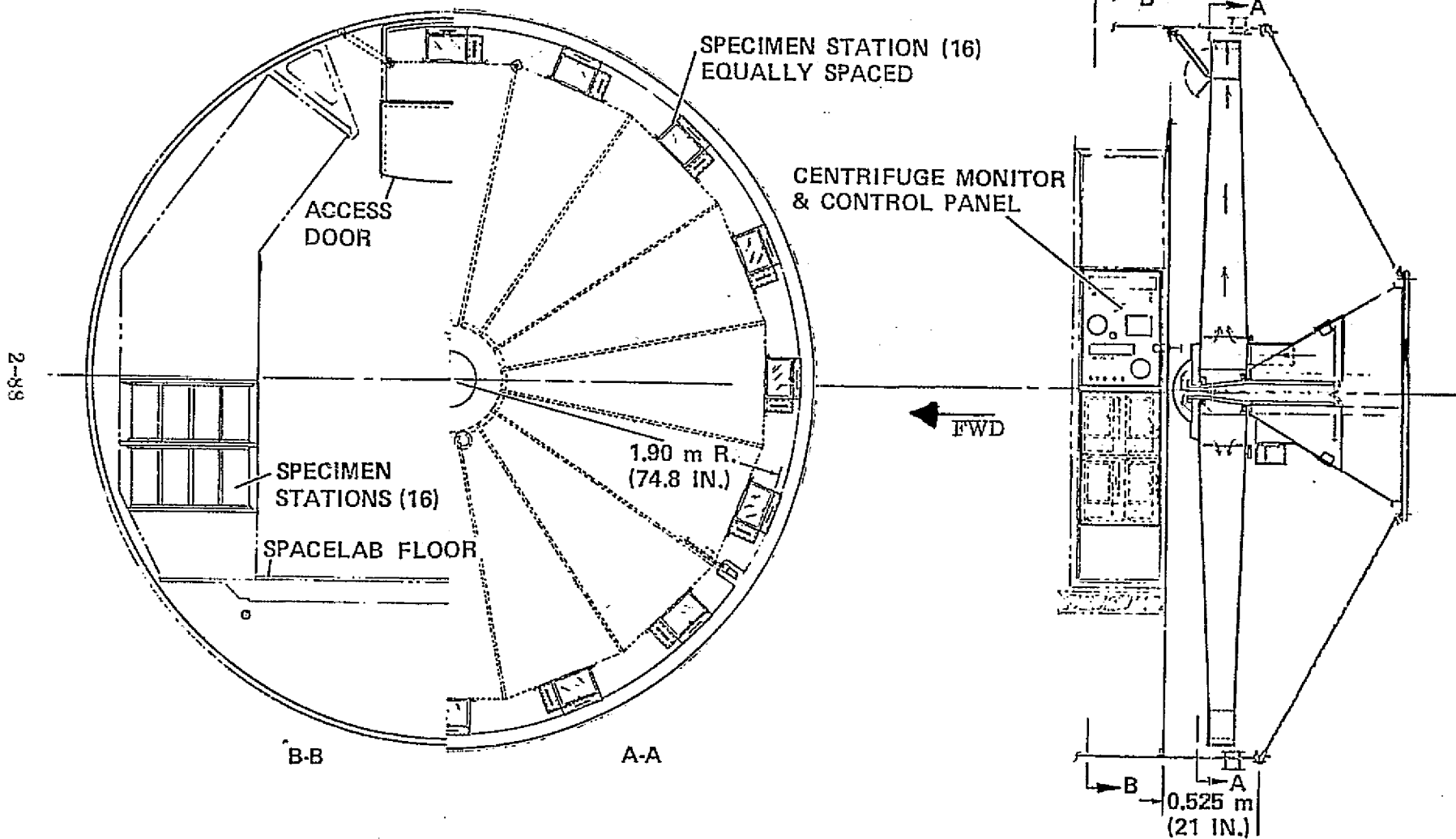
The August 1973 Life Sciences Working Group meeting established the requirement that an on-board research centrifuge be included in the Life Sciences Shuttle Laboratory. This was formalized in Memo: MMC73-M444; MM/NASA Director for Life Sciences to MD-T/Dep. Assoc. Admin.-Technical, August 17, 1973. GDCA, through its Shuttle Systems Payload Data Activity (SSPDA), was asked to provide an initial concept of the centrifuge. The design activity proceeded under the direction of the SSPDA Life Sciences specialist and the result was documented in the final SSPDA report (Summarized NASA Payload Descriptions - MSFC Report, October 1973). Although the centrifuge was documented as a separate payload, it is always flown with the Life Sciences Shuttle Laboratory. The design is still conceptual.

### Technical Description

Based on the preliminary guidelines, a centrifuge was designed. The estimated properties of the conceptual design, shown in the accompanying figure, are:

Weight of rotating elements:	146 kg (321 lb)
Total weight, open loop ECS:	250 kg (550 lb)
Δ closed loop ECS weight:	104 kg (229 lb)
Envelope volume:	6.8 m <sup>3</sup> (240 ft <sup>3</sup> )
Power:	210 w - drive
	<u>144 w - cage lighting</u>
	354 w - total
Angular velocity: for 1 g	2.27 rad/s (21.7 rpm)
for 3 g	3.93 rad/s (37.6 rpm)
Moment of inertia:	470 kg-m <sup>2</sup> (11,120 lb-ft <sup>2</sup> )
Angular momentum (3g):	1850 N-m-sec (13,350 lb-ft-sec)

Development Time: 48 months.



## E.I. 44 CHEMICALS

(E.U. 4 - Preparation & Preservation Unit)

### Purpose

To provide miscellaneous pre-packaged and pre-measured chemicals needed for life sciences research.

### Requirements

Requirements will be experiment-specific.

### Hardware Status

Rating: Repackage.

Commercial chemicals and some commercial packaging techniques should be usable. .  
Also, some special dispensing and hold-down provisions will have to be developed.

### Technical Description

Estimated properties of chemicals for a Dedicated Laboratory, 7-day mission are:

Weight:	0.5 kg (1.1 lb)
Volume:	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )
Power:	0

Development Time: 6 months.

E.I. 44A CHEMICALS, RADIOISOTOPE TRACERS  
(E. U. 4 Preparation and Preservation Unit.)

Purpose

For injection into organisms to act as tracers.

Requirements

To be determined.

Hardware Status

Rating: Re-package

These chemicals are commercially available. Special packaging designs may be required.

Technical Description

The following weight and volume including packaging were assumed:

Weight	0.3 kg (0.6 lb)
Volume	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )
Power	0

Development Time: 6 months

E.I. 45 CHEMICAL STORAGE CABINET  
(E.U. 7 Ancillary Storage Unit.)

Purpose

This cabinet is used for room temperature chemical storage through all mission phases.

Requirements

1. Size, number, and compartment configuration: tbd
2. Must hold down and cushion containers.
3. Hermetic sealing desirable in case of spills, outgassing of chemical containers, etc.
4. Connection to ECS contaminant control loop desirable.

Hardware Status

Rating: Redesign

This item must be designed and fabricated.

Technical Description

Estimated flight item properties are:

Weight: 4 kg (8.8 lb)  
Volume: 14.1 dm<sup>3</sup> (0.5 ft<sup>3</sup>)  
Power: 0

Development Time: 12 months

E.I. 48 CLEANER, VACUUM  
(E.U. 6 Maintenance, Repair & Fabrication Unit.)

Purpose

To collect airborne debris including liquid droplets during experiment procedures.

Requirements

This vacuum cleaner is envisioned to be a small unit with the requirement to suck in and contain small airborne particles. The suction inlet is expected to be manually directed so that a small capacity unit can be effective. The air velocities produced by the vacuum should probably be on the order of five hundred feet per minute in the vicinity (about  $28 \text{ dm}^3$  or  $1 \text{ ft}^3$ ) of the vacuuming operation in order to overcome air velocities in the manned compartment which could be on the order of 50 fpm.

Hardware Status

Rating: Modification

Off the shelf commercial units could probably be used with minor modifications. Modifications might include changes in the type of power used, changes in the collection bag to accommodate liquid droplets, packaging changes, and wiring and materials changes to correspond to fire safety standards. Small portable battery powered vacuum cleaners are available for consideration, in addition to larger units generally powered by 60 Hz, 115 volt a.c. Because of the lack of gravity much less suction than required in ground units will be needed to move particles to the collection site.

Technical Description

The selection and design of this item have not yet been determined. A flight type unit is estimated at

Weight	2.3 kg (5 lb), including attachments
Power	100 watt
Volume	$10 \text{ dm}^3$ ( $0.35 \text{ ft}^3$ ), including attachments

Development Time: 18 months

E.I. 50 CLINOSTAT FOR PLANTS  
(E.U. 51 - Plant Research Support Unit)

Purpose

To slow down the plant organisms relative to the laboratory. This device is used in ground-based laboratories to neutralize the effects of gravity through slow rotation of the organism. It is included in the spacecraft equipment complement for the purpose of investigating its effectiveness in simulating zero-g and any artifacts that it may introduce relative to a true zero-g environment.

Requirements

Specific requirements are experiment specific. A small unit rotating in a single plane was assumed to be satisfactory for the life sciences laboratories. Rotation rates generally are between 0.1 to 2 rpm.

Hardware Status

Rating: Redesign

A variety of custom designed and built units are currently in use throughout various laboratories. No commercial source of these designs is known, but the design and construction of one for space use is not expected to present any problems.

Technical Description

The clinostat design used as a basis for this study is essentially a small rotating drum upon which the plants are mounted so that they grow radially outward from the drum. The following properties were estimated:

Weight:	3 kg (6.61b), excluding plants & media
Dimensions:	
Drum diameter	15 cm (5.9")
Drum length	20 cm (7.9")
Diametral clearance reqd. for the drum & plants	35 dm (13.8")
Envelope Volume:	
Clinostat	4 dm <sup>3</sup> (0.14 ft <sup>3</sup> )
Clinostat & plants	20 dm <sup>3</sup> (0.71 ft <sup>3</sup> )
Power & Heat Rejection:	10 watts (air cooled)
Data Management:	Monitor motor amperage

E.I. 50 (Cont'd)

Location:

Will generally be placed inside Plant  
Holding Unit (E.I. 101, E.U. 50)

Interfaces:

EPS, CDMS, & Plant Holding Unit

Development Time: 12 months

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E.I. 50A CLINOSTAT FOR CELLS AND TISSUES  
(E.U. 61 - Cells/Tissues Research Support Unit)

Purpose

To slowly rotate cells/tissues organisms relative to the laboratory. This device is used in ground-based laboratories to neutralize the effects of gravity through slow rotation of the organism. It is included in the spacecraft equipment complement for the purpose of investigating its effectiveness in simulating zero-g and any artifacts that it may introduce relative to a true zero-g environment.

Requirements

Specific requirements are experiment specific. A small unit rotating in a single plane was assumed to be satisfactory for the life sciences laboratories.

Hardware Status

Rating: Redesign

A variety of custom designed and built units are currently in use throughout various laboratories. No commercial source of these devices is known, but the design and construction of one for space use is not expected to present any problems.

Technical Description

The following properties were estimated for the clinostat:

Weight:	2 kg (4.4 lb)
Envelope Volume:	4 dm <sup>3</sup> (0.14 ft <sup>3</sup> )
Power & Heat Rejection:	10 watts (air cooled)
Data Management:	Monitor motor current
Location:	In Cells/Tissues Holding Unit (E.I. 98A, E.U. 60)
Interfaces:	EPS, CDMS, & Cells/Tissues Holding Unit

Development Time: 12 months

## E.I. 50B COMPACTOR, WASTE SOLIDS

(E.U. 6 Maintenance, Repair and Fabrication Unit.)

### Purpose

This unit will compact waste solids for easy handling.

### Requirements

Capability to compact wastes such as: wrappers, plastic disposable syringes, vials, metal containers, etc.

### Hardware Status

Rating: Modification

Commercial designs of scaled-down size should be usable. The Sears household compactor has the following properties:

Weight:	86 kg (190 lbs)
Size:	87 x 38 x 61 cm (34.5"H x 15"W x 24"D)
Volume:	0.2m <sup>3</sup> (7.2 ft <sup>3</sup> )
Motor:	1/3 HP (approx. 250 watts)
Compaction:	Final vol. = 1/4 initial vol.

### Technical Description

The following properties were estimated for a flight unit.

Weight:	18 kg (40 lb)
Envelope Volume:	113 dm <sup>3</sup> (4 ft <sup>3</sup> )
Power:	100 watts

Development Time: 18 months.

E.I. 51F COOLANT LOOP, LIQUID  
(E.U. 3 - Life Sciences Experiment Support Unit)

Purpose

This loop is needed to provide liquid coolant to life sciences laboratory equipment.

Requirements

This loop must transfer heat from cold plated loads throughout the laboratory to the Spacelab provided, experiment dedicated heat exchanger. The specific requirements of this loop will depend upon later detailed definition of experiment equipment, their cooling loads, and their temperature requirements. Dual redundant loops may be desirable due to the critical nature of the freezers and refrigerators which are likely to be cooled by this loop.

Hardware Status

Rating: Redesign

This loop will be similar in design to coolant loops used on past spacecraft. Some major components such as pumps, reservoirs, controls, valves and couplings may be identical to past space qualified components. Aircraft components may also be usable. Thus, no major development of new components or design concepts is foreseen.

Technical Description

The loop assumed herein for preliminary purposes uses water as a coolant, and stainless steel components and lines. The cold plates themselves were not included in the estimated properties shown below:

Weight:	30 kg (66 lb) (including water)
Volume:	25 dm <sup>3</sup> (.9 ft <sup>3</sup> ) plus distributed lines
Power:	50 watts, 28 v. d.c.
Heat Rejection:	50 watts (primarily to liquid coolant)
Data Management:	Monitor several coolant loop temperatures, pressures and flow rate. Low rate.
Interfaces:	Spacelab experiment heat exchanger and all E.I.s requiring liquid coolant.

Development Time: 12 months

E.I. 54 COUNTER, COLONY, MANUAL  
(E.U. 5 Biochemical and Biophysical Analysis Unit.)

Purpose

For use in the manual counting of bacterial colonies.

Requirements

Standard colony magnifier/counter.

Hardware Status

Rating: Modification

Commercial units are available which should be applicable to space use with minor modifications to accept spacecraft power supply in lieu of 115 volt 60 Hz in the commercial unit.

Reference (a) Quebec Colony Counter, Darkfield Illumination  
APHA, Americal Optical No. 3330.

Technical Description

A typical commercial unit consists of a  $4 \times 4.3 \times 4$  cm ( $10 \times 11 \times 10$  in.) box with 50 watt bulb inside, which illuminates a plate which is viewed through a magnifying glass, see attached figure. The properties of a flight-type unit are estimated below.

Weight	1.5 kg (3.3 lb)
Power	50 watts
Volume	$1.5 \text{ dm}^3$ ( $0.05 \text{ ft}^3$ )

Development Time: 6 months



C8375, C8376-1

**C8375**

**COLONY COUNTER, Darkfield, Quebec (AO 3330)** - For use in counting bacteria; colonies are presented against a dark background. Illumination provided by 40 or 50 watt tungsten bulbs;  $4\frac{1}{2}$ " lens offers 1.5X magnification and is positioned to eliminate parallax errors. Lens is focusable by sliding rod or may be swung away when not used; a second lens may be attached for greater magnification. Unit is complete with Wolfhugel guide plate; accommodates Stewart and Jeffers plates as well. Sheet metal case is finished in crinkled maroon enamel. Dimensions: 10"h x 11"w x 10"l. For operation on 115V, 60 Hz.

Order <b>C8375 - Counter</b>	Each <b>\$161.00</b>
	5, ea <b>144.90</b>

REPRODUCIBILITY OF THE  
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E.I. 63B DISPLAY-KEYBOARD, PORTABLE  
(E.U. 2 Data Management Unit.)

Purpose:

A general purpose CRT display and response keyboard linked to the Spacelab CDMS computer that provides information, operating instructions, etc., for the crew on demand. Replaces instruction manuals, checklists, etc.

Requirements:

1. Provide a general purpose CRT that can display alphanumeric data in instruction and question formats, detailed schematics, flow charts, etc.
2. Provide a general purpose response keyboard that contains the standard alphanumeric input keys as well as multi-function special purpose keys.
3. Provide a computer control system for stimulus presentation and response interpretation and recording.

Hardware Status:

Rating: Modification

The IMBIM's Complex Behavioral Processes Assembly may be adaptable for use. It provides the necessary general purpose display, keyboard, and central computer linkup.

Technical Description:

Estimated values:

Weight:	13.6 kg (30 lb)
Volume:	42.5 dm <sup>3</sup> (1.5 ft <sup>3</sup> )
Power:	60 watts

Development Time: Approximately 6 mos.

E.I. 63C DISPLAY, NUMERIC  
(E. U. 2 Data Management Unit.)

Purpose

To display data at various places within the life sciences laboratory. The signals displayed will generally emanate from equipment sensors and outside sources such as the command and data management subsystem (CDMS).

Requirements

The display characteristics have yet to be determined. The major use will be the display of sensor outputs. Probably two 4-digit displays would be adequate. Symbols should be readable from approximately one meter from the display. Also, selector switches would be required with the display in order to select the signal to be displayed.

Hardware Status

Rating: Re-package

Commercially available equipment should be adaptable for use.

Technical Description

Estimated properties of a flight display, selector switches, and electrical interconnections are:

Weight	2 kg (4.4 lb)
Volume	4 dm <sup>3</sup> (0.14 ft <sup>3</sup> )
Power	2 watts

Development Time: 6 months

## E.I. 64 ECG COUPLER

(E.U. 2 Data Management Unit)

### Purpose

To condition ECG voltage signals for transmission to the CDMS, recording devices, or display devices.

### Requirements

Couplers will be required for humans, primates, and small vertebrates.

### Hardware Status

Rating: Re-package

Existing electronics components and packaging designs should be usable.

### Technical Description

Estimated properties of a typical ECG coupler are:

Weight:	0.2 kg (0.44 lb)
Volume:	0.5 dm <sup>3</sup> (0.018 ft <sup>3</sup> )
Power:	2 watts
Heat Rejection:	2 watts (to air)

Data Management: The CDMS sampling rate required will depend upon the organism being monitored. The rate used for preliminary purposes was 500 samples/sec. (7 bits per sample).

Location: ECG couplers should be located close to the source of the ECG signals. They will be located within the holding units for primates and small vertebrates.

Interfaces: Structural interfaces will exist between these couplers and the holding units, the work and surgery bench, and the Spacelab racks.

Electrically interfacing items include the crew, the organisms, the CDMS (RAUs), the strip short recorder (EI 150A, EU 1) the oscilloscope (EI 132, EU 2).

Development Time: 6 months

## E.I. 65 EEG COUPLER

(E.U. 2 Data Management Unit.)

### Purpose

To condition EEG voltage signals for transmission to the CDMS, recording devices, or display devices.

### Requirements

Couplers will be required for humans, primates, and small vertebrates.

### Hardware Status

Rating: Re-package

Existing electronics components and packaging designs should be usable.

### Technical Description

Estimated properties of a typical EEG coupler are:

Weight:	0.2 kg (0.44 lb)
Volume:	0.5 dm <sup>3</sup> (0.018 ft <sup>3</sup> )
Power:	2 watts
Heat Rejection:	2 watts (to air)

Data Management: The CDMS sampling rate used for preliminary purposes was 500 samples/sec. (7 bits per sample).

Location: EEG couplers should be located close to the source of the EEG signals. They will be located within the holding units for primates and small vertebrates.

Interfaces: Structural interfaces will exist between these couplers and the holding units, the work and surgery bench, and the Spacelab racks. Electrically interfacing items include the crew, the organisms, the CDMS (RAUs), the strip chart recorder (EI 150A, EU 1) the oscilloscope (EI 132, EU 2).

Development Time: 6 months

E.I 65 B ELECTROPHYSIOLOGY BACKPACK  
(E.U. 12 Biomedical/Behavioral Research Support Unit.)

Purpose:

A backpack containing the necessary electronics for sensing and transmitting man's physiological data such as ECG, EEG, EMG, EOG, etc.

Requirements:

Provide the necessary sensors, signal conditioners, and transmitters to sense and transmit ECG, EEG, EMG and EOG data.

Provide a portable man-mounted unit that minimizes weight and volume so as to minimize interference with and degradation of the test subject's performance.

Hardware Status:

Rating: Modification

Commercially available units may be suitable for use with modifications. An ECG transmitter (Hewlett Packard Model 781000A) is described in the catalog sheets attached to the write-up for Electrophysiology receiver (EI 65C, EU 12).

Technical Description:

Estimated Values are based on the Hewlett-Packard ECG Transmitter, Model 78100A.

Weight:	0.3 kg (0.7 lb)
Volume:	0.23 dm <sup>3</sup> (0.01 ft <sup>3</sup> )
Power:	0 watts (battery powered)

Development Time: 12 months.

E.I. 65C ELECTROPHYSIOLOGY RECEIVER  
(E.U. 12 Biomedical/Behavioral Research Support Unit.)

Purpose

To provide special reception of cardiovascular and neural electrophysiological events via biotelemetry systems. This receiver is predominantly for biomedical experiments involving man.

Requirements

EEG (electroencephalogram) monitoring and the following cardiologic studies:

- Electrocardiogram (ECG)
- Vectorcardiography (VCG)
- Balistocardiography (BCG)
- Impedance Cardiography (ZCG)
- Phonocardiography (PCG)

Hardware Status

Rating: Modification

Many types of clinically oriented and some flight rated units are available. Minimum modification will be required for commercial units.

Technical Description

Estimated properties of a flight unit are based upon the Hewlett-Packard Model 78101A.

Weight:	2.7 kg (6 lb)
Dimensions:	8.9 cm × 20 cm × 28 cm (3.5 × 7.0 × 11 in.)
Volume:	5 dm <sup>3</sup> (0.18 ft <sup>3</sup> )
Power:	25 watts (maximum)
Input Impedance:	50 ohms nominal
Antenna:	7 in. monopole

Development Time: 12 months.

# PATIENT MONITORING

*medical instrumentation*

model 78100A,  
78101A  
telemetry  
system



The Hewlett-Packard Telemetry System consists of the Model 78100A pocket-sized transmitter and the Model 78101A modular receiver. Using radio waves, the transmitter sends a patient's ECG to remote monitoring equipment, which may display the ECG waveform or heart rate, detect and analyze cardiac arrhythmias, and display alarm or inoperative conditions. Hewlett-Packard Telemetry offers the following benefits to your monitoring facility:

**SIGNAL CLARITY** — Special innovations contribute to an ECG signal with outstanding fidelity. The transmitter minimizes false indications due to motion and pacing artifacts.

**DURABILITY** — Modern materials add durability and reliability to the equipment. The lightweight transmitter case is molded of durable, glass-filled polypropylene. There is no external antenna to catch in clothing or be broken off. The heavy-duty polypropylene electrode set cannot be damaged by most hospital solvents, and its standard ECG connector is usable with telemetry or hard-wired systems.

**SIMPLE CONTROL** — Only one standard, low-cost mercury battery is required for 72 continuous hours of operation. When the battery is inserted into the transmitter and locked into place, transmission begins, with no adjustments of the transmitter or receiver required. Because there is no power switch, the transmitter cannot be turned off inadvertently.

**AUTOMATIC INOPERATIVE INDICATIONS** — The front panel **RANGE/BATTERY** inoperative light illuminates if the transmitter battery needs replacement or if the patient exceeds the effective transmission range. The **ELECTRODE** inoperative light illuminates if one or more electrodes become detached. In both inoperative modes, the receiver inhibits alarms and grounds the ECG output to keep incorrect ECG information off the monitors.

HEWLETT  PACKARD

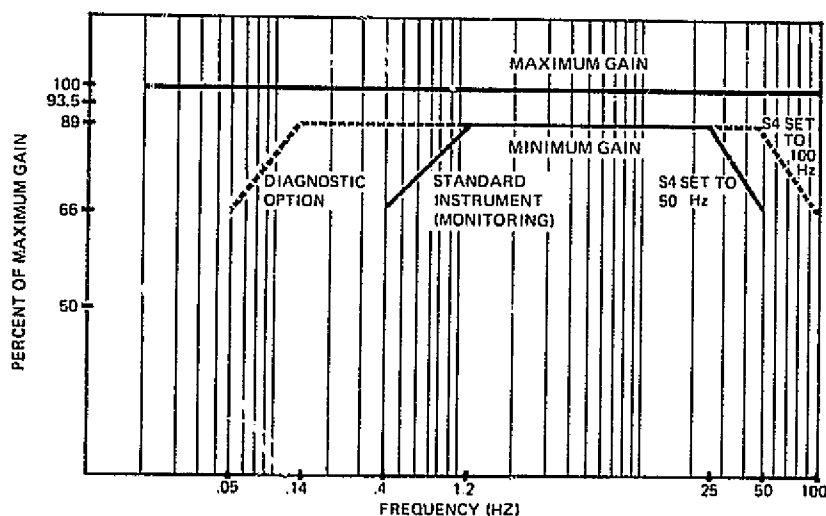
## ECG CHANNEL

**Differential Input:** Defibrillator-protected. Input impedance greater than 10 megohms below 60 Hz. Input range is  $\pm 5$  millivolts.

**Pace Pulse Rejection:** Slew-rate limited to a nominal 0.25 millivolts per millisecond, referred to the input (except Option 021), which attenuates the pace pulse, minimizes ECG waveform distortion, and minimizes the probability of pace pulse triggering of a Cardiotelemetry.

**ECG Amplification:** Internally switched to a gain of 1000, 50 or 1. Gain stability is  $\pm 7\%$ , and gain accuracy at  $25^{\circ}\text{C}$  is  $\pm 5\%$ . For display size control, receiver can be switched at the front panel from fixed gain to variable gain. Variable gain gives amplification of 20% to 400% of switch setting.

## ECG Frequency Response:



NOTE: Signal amplitudes must be small enough not to be limited by pace pulse rejection circuits.

**Noise at ECG Output:** 10  $\mu\text{V}$  rms maximum (80  $\mu\text{V}$  peak-to-peak), referred to input, with each ECG lead connected to the same point through a 25K shielded resistor for a received RF signal of greater than  $10^{-13}$  Watts.

**Calibration Voltage:** 1 mV, referred to input, and is added to ECG output by pressing front panel pushbutton. Accuracy at  $25^{\circ}\text{C}$ :  $\pm 6\%$  referred to input.

**Output Impedance:** Less than 55 ohms.

**Electrode Inoperative Indication:** Receiver front panel light for detached electrode.

**Range/Battery Inoperative Indication:** Receiver front panel light for low battery voltage, patient out of range, or excess radio interference.

**Channel Inoperative System Signal:** Occurs with inoperative conditions, and ECG output is grounded.

**ECG Output:** Compatible with HP heart rate meters, scopes, recorders and arrhythmia monitor. It is also compatible with most manufacturers' ECG monitors and displays.

## TRANSMITTER, MODEL 78100A

**RF Power Output:** 2 mW into 50 ohm load ( $\pm 0.75$  mW) measured from RL electrode connector to a ground plane under transmitter.

**Frequency Range:** Carrier 450 to 470 MHz.

**Frequency Stability:**  $\pm 0.0006\%$  (crystal controlled).

**Modulation Type:** FM/FM.

**Battery Power:** One disposable, 8.4 volt mercury cell (Mallory TR146X or equivalent), with life of 72 continuous hours of operation.

**Physical Characteristics:** Case, glass filled polypropylene, 12.7 x 7.4 x 2.4 cm (5.0 x 2.9 x 0.95 inches). Weight, 267 grams (9.5 oz) including battery. Color, Jade Gray. Operating Temperature,  $0-55^{\circ}\text{C}$  ( $32^{\circ}-131^{\circ}\text{F}$ ).

## RECEIVER, MODEL 78101A

**Antenna:** Vertical, 7-inch monopole on top cover. Remote antenna optional.

**Radio-frequency Input Impedance:** 50 ohms nominal.

**Frequency Tuning:** Crystal-controlled.

**Outputs:** One ECG telephone jack on rear panel, and two REMOTE connectors that match Hewlett-Packard monitor system cabling.

## Controls and Indicators:

Internal Gain Switch

Std/Variable Size Switch

Variable Size Control

Inoperative Indicators on front panel

1 mV Calibration button

ON-OFF indicator light and mechanical indicating lines on POWER button.

**Power Requirements:** Receiver, 115/230 Vac  $\pm 10\%$ , 48 to 66 Hz, 25 VA max.

**Auxiliary Power Outlet:** Unswitched IEC female receptacle provides up to 735 VA for auxiliary equipment.

**Physical Characteristics:** Case, 8.9 cm high x 20 cm wide x 27.9 cm deep (3.5 x 7.87 x 11 inches). For case height without feet, subtract 1.3 cm (0.5 in.). Olive-gray vinyl panels with white front and brushed-aluminum trim, Jade Gray knobs. Channel number plate. Front panel has blank area about 2.5 x 12.5 cm (1 x 5 in.) for patient's name or bed number if desired. Weight, 2.7 kg (6 lb). Operating Temperature,  $0-55^{\circ}\text{C}$  ( $32-131^{\circ}\text{F}$ ).

## PRICES AND OPTIONS

## PRICES AND OPTIONS

Telemetry Channel consisting of 78100A Transmitter and 78101A Receiver \$1800.00

78100A Transmitter . . . . . \$600.00

Option 021: Provides diagnostic bandwidth of .05 Hz to 100 Hz instead of standard bandwidth of 0.4 to 100 Hz

. . . . . No additional charge

Option 022: Replaces reusable electrodes with 14121A Cable Assembly and 14097A Disposable Electrodes

No additional charge

78101A Receiver . . . . . \$1200.00

Option 023: Replaces standard 8 ft. power cord with 76 cm (2.5 ft.) NEMA male to IEC female power cord, 8120-1405.

. . . . . No additional charge

Option 030: Replaces standard 8 ft. power cord with 76 cm (2.5 ft.) IEC male to IEC female power cord, 8120-1396.

. . . . . No additional charge

The following antenna options are arranged so that if antenna or package option is selected, one option out of Group A and one option out of Group B must be included.

## Group A:

Option 025: Replaces receiver top-mounted antenna with Remote Antenna 14094A, including long cable and bracket for mounting on wall or ceiling. Specify required cable length, 6.1 to 61M (20-200 ft.) . . . \$ 175.00

Option 028: Replaces Receiver top-mounted antenna with Remote Antenna 14094A, including short cable and bracket for mounting on wall or ceiling. Specify length up to 6.1M (20 ft.) . . . . . 100.00

Option 029: Replaces Receiver top-mounted antenna, with RF T-Connector and short (1-20 ft.) RF cable for connection to a shared antenna. . . No additional charge

## Group B:

Option 024: Kit for mounting another 7.87 in. wide, HP standard module on top of 78101A Receiver . . . No additional charge

Option 032: Perforated covers for installation in Central Station Case Model 7832A . . . . . No additional charge

Option 033: Solid, blank top cover . . . . . No additional charge

## ACCESSORIES

## ACCESSORIES SUPPLIED

## Transmitter Accessories

REDUX Electrolyte 651-1021  
Cream, 5 oz.

8.4-Volt Battery 1420-0031

Pouch and Belt 1530-1693

Electrode Adhesive Discs\* 14095B

Electrode and Cable Set\* 14120A

\*For Option 022 substitute:

Disposable Electrode Set 14097A

Electrode Cable 14121A

## Receiver Accessories

Fuse, 0.125A (230V Service) 2110-0027

Power Cord, 8 ft \*\* 8120-1395

Operating Manual 78101-91998

Operating Instruction Card 78101-91999

\*\*For Option 023 substitute:

Power Cord, 30 inch 8120-1405

\*\*For Option 030 substitute:

Power Cord, 30 inch 8120-1396

## ACCESSORIES AVAILABLE

Disposable Electrode Set 14097A  
(less cable)

Cable for Disposable Electrodes 14121A

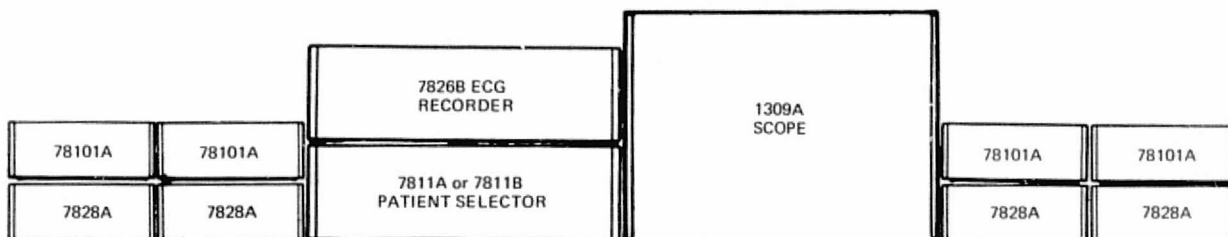
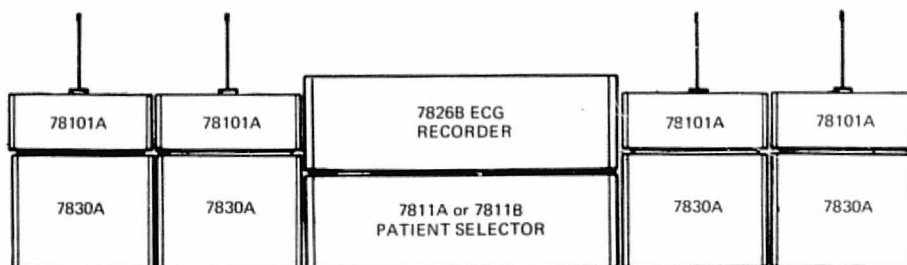
Electrode Adhesive Discs 14095A  
(with Micropore® Tape)

External Antenna (less cables), with mount 14094A

Maintenance Manual 78101-91997  
(Principles of Operation, Maintenance Procedures, Parts List and Schematic Diagrams). Note that a second-class radiotelephone operator must supervise all repairs that affect r-f emission.

**FLEXIBLE INSTALLATION** — The Hewlett-Packard modular concept permits designing a specific monitoring system to suit your needs, and the small module size conserves valuable central station space. This modular flexibility also permits adding on, and easy installation of remote monitors or relocation of bedside units. The addition of telemetry makes a Hewlett-Packard monitoring system even more flexible for your extended care patients since they need not be confined to fixed instrument locations.

**TYPICAL  
INSTRUMENT  
COMBINATIONS  
FOR ECG  
TELEMETRY**



For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181 • West (213) 877-1282. Or, write: Hewlett-Packard, Medical Electronics Division, 175 Wyman Street, Waltham, Massachusetts 02154. In Europe, HPSA 1217 Meyrin, Geneva. For rest of world, HP Intercontinental, 3200 Hillview Avenue, Palo Alto, California 94304.

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## E.I. 66 EMG COUPLER

(E.U. 2 Data Management Unit)

### Purpose

To condition EMG voltage signals for transmission to the CDMS, recording devices, or display devices.

### Requirements

Couplers will be required for humans, primates, and small vertebrates.

### Hardware Status

Rating: Re-package

Existing electronics components and packaging designs should be usable.

### Technical Description

Estimated properties of a typical EMG coupler are:

Weight:	0.2 kg (0.44 lb)
Volume:	$0.5 \text{ dm}^3$ ( $0.018 \text{ ft}^3$ )
Power:	2 watts
Heat Rejection:	2 watts (to air)

Data Management: The CDMS sampling rate used for preliminary purposes was 500 samples/sec. (7 bits per sample).

Location: EMG couplers should be located close to the source of the EMG signals. They will be located within the holding units for primates and small vertebrates.

Interfaces: Structural interfaces will exist between these couplers and the holding units, the work and surgery bench, and the Spacelab racks. Electrically interfacing items include the crew, the organisms, the CDMS (RAUs) the strip chart recorder (EI 150A, EU 1) the oscilloscope (EI 132, EU 2).

Development Time: 6 months

## E.I. 70C EQUIPMENT RESTRAINT DEVICE

(E.U. 3 Life Sciences Experiment Support Unit.)

### Purpose

To hold small biomedical equipment that the crewman will be working with in the 0-g environment.

### Requirements

This device would be used to hold down capillary tubes, vacutainer tubes, petri dishes, sensors and probes, swabs, wipes, pipettes, tools, etc.

Several types of hold-downs may be necessary to accommodate all the various types of research equipment.

### Hardware Status

Rating: Re-design

Hold downs of various types have been used in past space flights. However, the unique life science laboratory test procedures and equipment may require special designs. One such design is shown in the attached sketch.

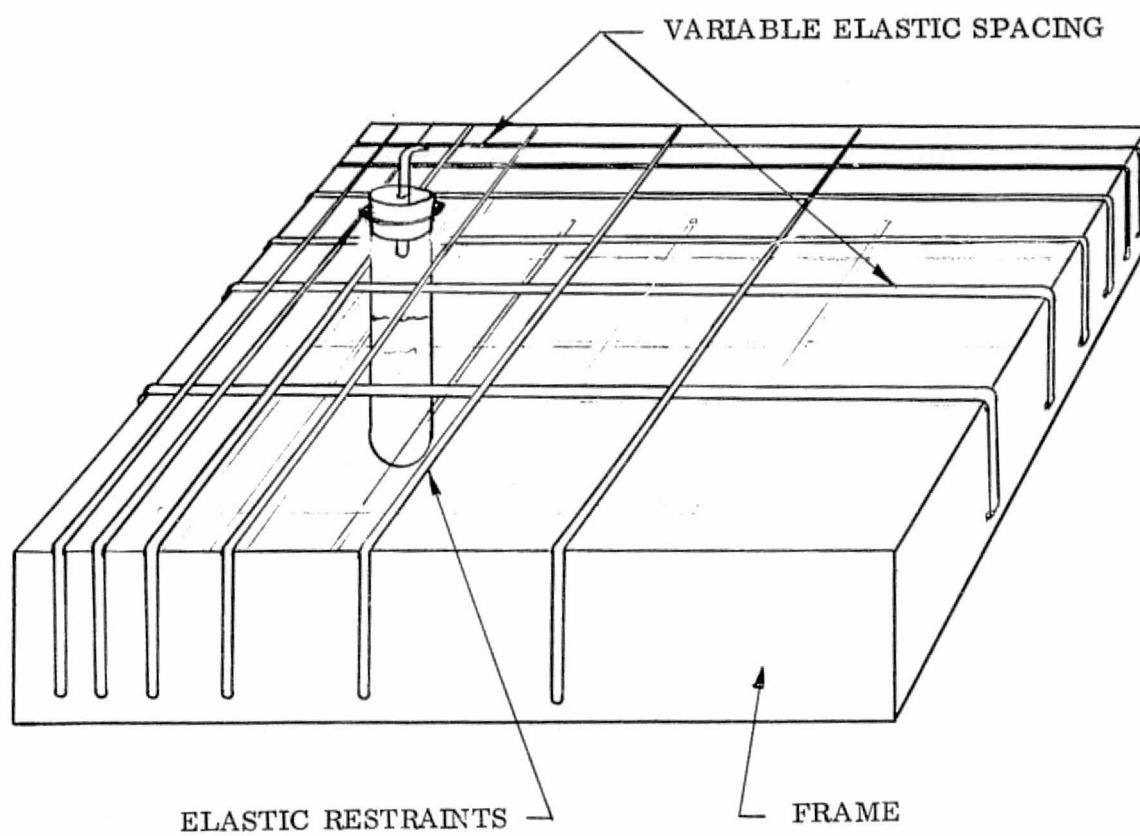
### Technical Description

The following weight and volume were estimated:

Weight	0.5 kg (1.1 lb)
Volume	1 dm <sup>3</sup> (0.035 ft <sup>3</sup> )

Development Time 9 months

E.I. 70C EQUIPMENT RESTRAINT DEVICE (Cont)



EQUIPMENT RESTRAINT DEVICE

E.I. 70E EXERCISE EQUIPMENT, PHYSIOLOGICAL  
(E. U. 31 BIOMEDICAL RESEARCH SUPPORT UNIT)

Purpose

The exercise equipment may serve two purposes. It will be needed in some cases to provide a known crew work-rate for metabolic or energetic studies. Secondly, it will be tested in order to determine optimum exercise regimens and equipment for use in long duration null gravity exposure.

Requirements

Specific requirements have not been defined. The Skylab astronauts utilized four devices, and these were used as the basis of the equipment described below. These were, (1) a bicycle ergometer, (2) a mini gym, (3) a treadmill, and (4) a spring pull device.

Hardware Status

Rating: Re-package

Modified Skylab equipment should be applicable. The treadmill was added to the Skylab equipment inventory during the course of the mission. It's design was of a make-shift nature utilizing a teflon friction surface and bungee hold-downs. However, the device reportedly worked well and provided exercise similar to earth-based walking, running and jumping. It has been assumed herein that for future missions the Skylab treadmill design will be updated to include a movable running surface.

Technical Description

**Bicycle Ergometer:** The ergometer is a bicycle-type device designed to allow the subject astronaut to exercise in a zero-g environment using either his hands or feet to drive the ergometer. It has an adjustable seat and handlebars. The ergometer is capable of providing work loads to produce either manually selected crew heart rates or automatic programmed heart rates. The following properties were estimated for a future version of the ergometer including a modified restraint system, the work load dynamometer, and control and display console.

Weight:	68 kg (150 lb)
Envelope dimensions:	127cm long x 58.4cm wide x 102cm high (30 x 23 x 40 inches)
Envelope volume:	757 dm <sup>3</sup> (26.7 ft <sup>3</sup> )
Power:	18 watts, 28 volt., d. c.
Heat Rejection:	18 watts + power input by user (tbd)
Data management:	Monitor, ergometer output, 0-300 watts, Speed, 40-80 rpm, motor control, 12 levels, on-off control, 2 levels Heart rate; 60-200 bpm, Body temperature, 308 to 314° K (95-105° F).

E.I. 70E EXERCISE EQUIPMENT, PHYSIOLOGICAL (continued)  
(E.U. 31 BIOMEDICAL RESEARCH SUPPORT UNIT)

**Location:** The bicycle ergometer subject (rider) will sometimes be monitored by the cardiopulmonary analyzer (E.I. 38F, E.U. 31) and some of the electrophysiological couplers. Thus, the ergometer should be located close to these items. It is imperative that it be located near the cardiopulmonary analyzer because breathing hoses must be connected to the analyzer and the length of these hoses must be kept as short as possible.

**Interfaces:** Interfaces exist with the cardiopulmonary analyzer (see above), the ECG and VCG couplers, the CDMS, and EPS.

**Mini-Gym:** The mini-gym used on Skylab was a modified version of Super Mini-Gym, Model 180, manufactured by Mini Gym, Inc., P. O. Box 266, 909 W. Lexington, Independence, Mo., 64051, Tel. (816)836-1300. Modifications included:

1. Use of an aluminum frame and cover.
2. Replacement of the nylon rope with one of polybenzimidazole (PBI).
3. Use of special mounting triangles and cleats.
4. Use of Dupont Krytox 240AC lubricant.
5. Addition of a shield around much of the brake fiber to minimize ejection of particles into the cabin.
6. The lead weight was replaced by stainless steel.
7. Steel components were nickel plated for corrosion protection in the oxygen enriched Skylab atmosphere.
8. An uncoiled brake fiber was used.
9. The force measurement mechanism was not used.

Properties of the flight unit including accessory handles, fittings, etc., were estimated as follows:

<b>Weight:</b>	7 kg (15.4 lb)
<b>Envelope volume:</b>	6 dm <sup>3</sup> (.21 ft <sup>3</sup> )
<b>Power:</b>	0
<b>Heat rejection:</b>	tbd (frictional heat production will depend upon work load)
<b>Data management:</b>	Manual entry of all data is anticipated.
<b>Location:</b>	Normally stored. Mounting brackets required where there is sufficient room for crewmen to exercise. Skylab used triangular grid floor brackets for mounting.
<b>Interfaces:</b>	Mounting brackets must be compatible with Spacelab equipment and structure.

E.I. 70E EXERCISE EQUIPMENT, PHYSIOLOGICAL (continued)  
(E.U. 31 BIOMEDICAL RESEARCH SUPPORT UNIT)

Spring Pulls: Spring pull exercise devices were used on Skylab. Estimated properties are:

Weight:	1 kg (2.2 lb.)
Stowed volume:	6 dm <sup>3</sup> (0.21 ft <sup>3</sup> )
Power:	0
Heat rejection:	Negligible

No special data management, placement, interface, or operational considerations are foreseen.

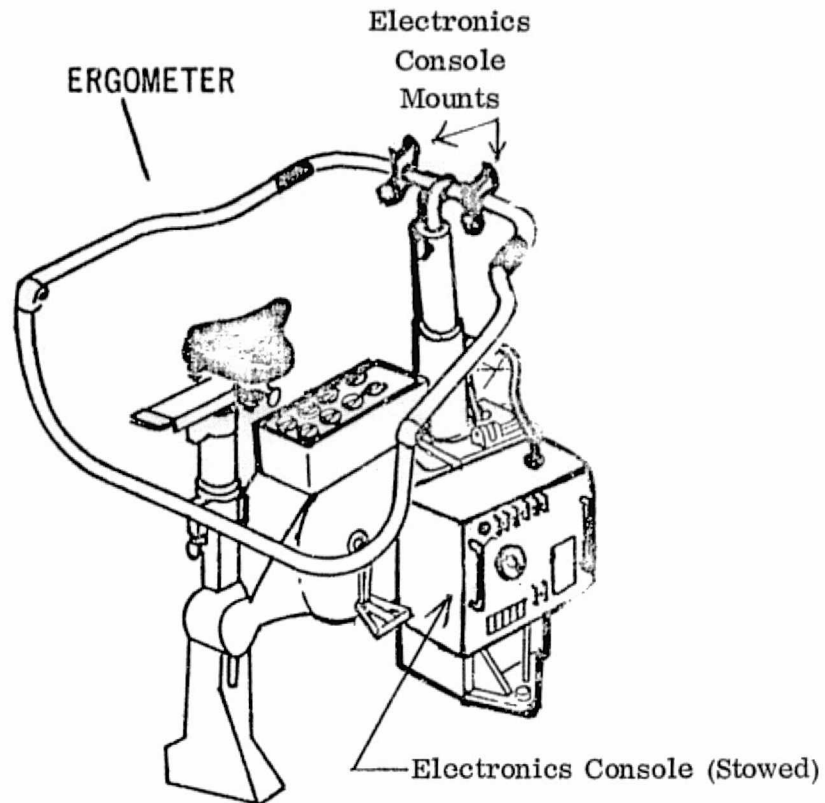
Treadmill: Due to the good results with the "Thornton" treadmill on Skylab, a treadmill will probably be developed for future flight use. A treadmill utilizing a simple (no dynamometer) belt-roller-friction system was assumed in estimating the following properties.

Weight:	20 kg (44 lb.)
Dimensions:	Stowed, 6.1 × 12.2 × 3 dm (2 × 4 × 1 ft) Operating (including subject), 6.1 × 12.2 × 21.3 dm (2 × 4 × 7 ft).
Volume:	Stowed, 223 dm <sup>3</sup> (7.9 ft <sup>3</sup> ) Operating envelope, 1.59 m <sup>3</sup> (56 ft <sup>3</sup> )
Power:	0
Heat Rejection:	tbd. (frictional heating rate will depend upon work load. Heat rejected to air.)
Data management:	Monitor, Speed, 2.4 to 9 m/sec (8-30 ft/sec) Heart rate, 60-200 bpm, Body temperature, 308 to 314°K (95 to 105° F).
Location:	Place near cardiopulmonary analyzer (E.I. 38F, E. U. 31).

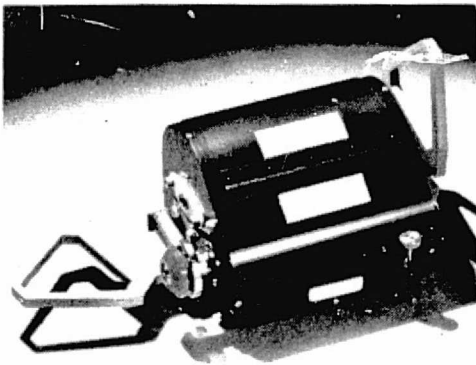
Total Weight, Power and Volume: Total weight, power, and volume for all the exercise devices described above are:

Weight:	68 + 7 + 1 + 20 = 96 kg (212 lb.)
Volume:	757 + 6 + 6 + 223 = 992 dm <sup>3</sup> (35 ft <sup>3</sup> ) (equipment only)
Power:	18 watts

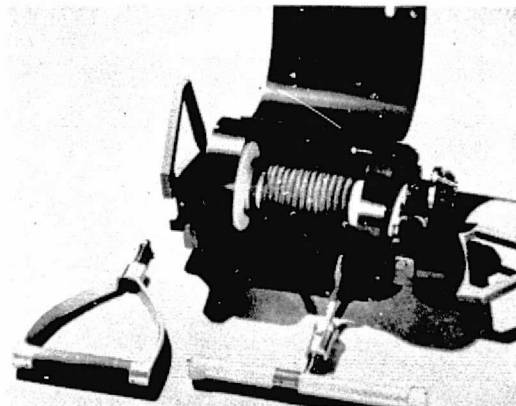
Development Time: 12 months



Bicycle Ergometer Used on Skylab. (Figure taken from Skylab Program Operational Data Book, Rept. No. MSC-01549, V. I, Rev. A, NASA/MSFC, Houston, TX, Oct. 1972.



The Mini-Gym designed and permanently installed in Skylab. Notice foot pads to receive cleats on astronauts boots.



The bottom of the exerciser Adaptor shows how the exerciser attached to ceiling and walls of the space craft.

Mini-Gym Used on Skylab.

E.I. 75C FILM, CINE  
(E.U. 1 Visual Records & Microscopy Unit.)

Purpose

This film is for use in the cine cameras for documentation of experiment events and phenomena.

Requirements

Requirements have yet to be determined. The amount of film required can vary substantially depending upon the specific experiments. The type of film may also depend upon the specific experiments.

Hardware Status

Rating: Space Qualified

For purposes of laboratory conceptual design, the 16 mm cine film cassettes which were used on Skylab were assumed to be usable.

Technical Description

The individual 16 mm film cassettes have the following properties:

Weight	0.54 kg (1.2 lb)
Size	2.54 cm × 16.5 cm dia. (1" × 6.5 " dia.)
Volume	0.54 dm <sup>3</sup> (0.02 ft <sup>3</sup> )
Film Length	122 m (400 ft) (~ 45 minutes of filming)

Development Time: None

E.I. 75F FILM, POLAROID  
(E.U. 1 - Visual Records and Microscopy Unit)

Purpose

Film packs for Camera, Polaroid (E.I. 33, E.U. 1).

Requirements

Film packs must fit the Polaroid SX70.

Varied types of film will be required and will depend upon the experiments.

Hardware Status

Rating: Space Qualified.

Polaroid film was used on Skylab.

Technical Description

Based on the Skylab self-developing film assembly (Skylab Stowage List Item No. 0122.02.00), the properties are:

Weight: Film, self-developing	0.113 kg (0.25 lb)
Stowage Bag, Film	0.045 kg (.1 lb)
Film + Bag	0.158 kg (0.35 lb)
Dimensions:	11.2 × 8.9 × 1.3 cm (4.4 × 3.5 × 0.5 inches)
Volume:	0.130 dm <sup>3</sup> (0.005 ft <sup>3</sup> )
Frames per film pack:	10
Power & Heat Rejection:	0
Data Management:	None
Location:	Store in Skylab film storage container.

Development Time: None

E.I. 76C FILM, 35 MM  
(E.U. 1 - Visual Records and Microscopy Unit)

Purpose

Film cassettes for the 35 mm camera (E.I. 36, E.U. 1).

Requirements

Variable types of film will be required depending upon the experiments.

Hardware Status

Rating: Space Qualified.

Thirty-five mm film was used on Skylab and other past space flights.

Technical Description

Approximate properties of a standard cassette containing 36 frames are:

Weight:	127g (0.28 lb) (Skylab data)
Envelope Volume:	0.05 dm <sup>3</sup> (0.002 ft <sup>3</sup> )
Location:	Spacelab film storage container

Development Time: None

E.I. 76J FLOWMETERS  
(E.U. 3 Life Sciences Experiment Support Unit.)

Purpose

To measure gas and liquid flows to and from various test equipment.

Requirements

Specific requirements will depend upon the experiments being conducted. Flow measurements to and from the test equipment will most likely include spacecraft coolant (water), fresh water from storage, and gases from storage. Liquid flows are expected to be on the order of 0-100 kg/hr. Gas and liquid flows internal to individual test equipment were assumed to be part of that test equipment.

Hardware Status

Rating: Modification

Standard techniques can probably be utilized for flow measurements. Pressure drop devices such as laminar flow elements or orifices should be applicable in many cases. Hot wire anemometers may also be used for gas flow measurements. Differential pressure sensors for use with the pressure drop devices utilize either mechanical or solid state pressure sensing elements. Signals from these pressure transducers would probably be fed to the spacecraft data management subsystem for recording and display. Direct reading pressure gages are also available but may not be needed. A typical flow rate transducer is described in the attached specification sheets taken from:

Environmental Control and Life Support '71 Component Specifications,  
Report No. 18-4-008, Basic Subsystems Module Definition Study, Con-  
tract NAS9-6796, General Dynamics/Convair, 17 October 1967.

Technical Description

The weight, power and volume of a single pressure drop type flowmeter, including the pressure transducer and signal conditioner, are estimated below.

Weight:	0.5 kg (1.1 lb)
Volume:	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )
Power:	1 watt

Development Time: 6 months

# FLOW-RATE TRANSDUCER (APOLLO P/N 836112)

## PURPOSE

The flow-rate transducer measures the rate-of-flow of the process gas.

## DESCRIPTION

The transducer is powered by the 28 vdc supply of the spacecraft and operates over a flow range of 0.2 to 1.0 lb per hr. An electrical signal (0 to 5 vdc) proportional to the oxygen flow-rate is provided by the transducer. This signal is used for ground checkout, for the crew's visual information, via an indicator, and for telemetry data to be transmitted to a ground station. A static switch is actuated in the event of an overflow condition (at 1 lb per hr), which turns on an indicator light.

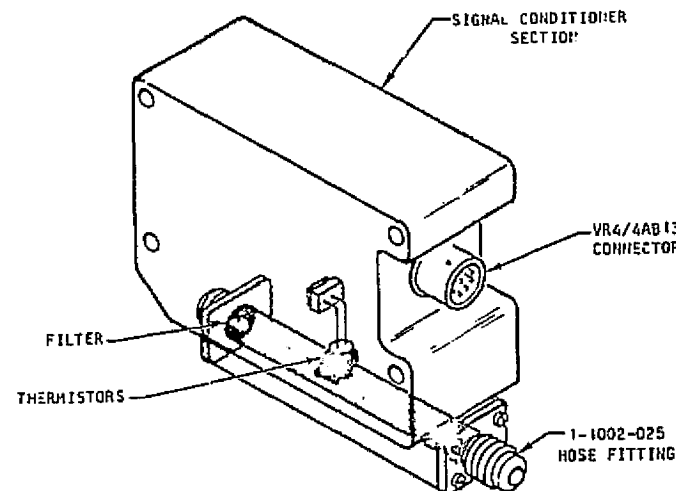
## PERFORMANCE AND DESIGN DATA

Operating flow range, lb/hr	0.2 to 1.0
Max overflow, lb/min	0.7 (42 lb/hr)
Accuracy, lb/hr	$\pm 0.048$ ( $\pm 0.30$ v) 0 to 150°F
Differential pressure	1.0 psi max at 1.0 lb/hr and 100 psig inlet 8.0 psi max at 0.7 lb/min and 100 psig inlet
Operating temp range, °F	-40 to +165 (ambient 0 to 150)
Time constant, sec	15 max (to 53.2% with applied step flow rate)
Output signal	0 v at 0.2 lb/hr at 5.0 vdc at 1.0 lb/hr 6.5 vdc max at greater flows
Output ripple, mv rms	Ripple component of output signal shall not exceed 10
Output load, ohm	30,000
Fitting ends	MS 33656-4 (1/4 in. OD tube)
Line pressure, psig	85 to 140 (100 nominal)

Proof pressure, psig	210
Burst pressure, psig	350
External leakage	$6 \times 10^{-6}$ lb/hr O <sub>2</sub> max with 140 psig internal pressure at 70°F
Electrical power requirements	
Input voltage, vdc	28 per SS-1070
Excitation current, ma	80 (max)
Weight, lb	1.0

## QUALIFICATION STATUS

The flow rate transducer is a qualified Block II Apollo component.



FLOW RATE TRANSDUCER

E.I. 77B FREEZER, CRYOGENIC  
(E.U. 4 - Preparation and Preservation Unit)

Purpose

To provide for rapid freezing of biological specimens.

Requirements

Maximum freezing rates, through direct immersion into liquid nitrogen, are required for some specimens according to UCSD scientists. However, lower freezing rates are also required. The reference cited below specifies a cooling rate of 1-10°C per minute for blood containing 10 percent glycerol, which is added to protect against hemolysis. Following freezing, specimens can be stored in the cryogenic freezer or in the Low Temperature Freezer (E.I. 81, E.U. 4).

Temperature:	77°K (-196°C or -320°F)
LN <sub>2</sub> Holding Time:	About 32 days

Hardware Status

Rating: SRT

A cryogenic freezer has been developed for the 7-day Apollo-Soyuz flight. It reportedly consists of a standard type of dewar filled with a capillary matrix material to hold the liquid nitrogen in the dewar. The matrix occupies the outer annulus of the dewar, the center portion being left open to receive the specimens.

Data on several Linde dewars for 1-g freezing applications are shown in the attached catalog sheet for reference. A cryogenic freezer which will provide direct immersion and operate in null gravity will require special development. Such a unit might be implemented by rotating a standard type of dewar or by otherwise providing circulation of the LN<sub>2</sub> within the dewar. Alternatively, a closed, floodable freezing chamber could be used. However, this would result in a substantial loss of LN<sub>2</sub> through boil-off every time the chamber was used.

Cryogenic freezer designs are being studied as a part of a current contract entitled "Advanced Refrigeration System Study". This contract is being funded out of NASA/MSFC (Contracting Officer's Representative is Jim Moses, Tel. No. 205/453-4474).

Technical Description

Until detailed studies are completed, the definition of the cryogenic freezer must be considered tentative. The following properties are based upon the use of LN<sub>2</sub>.

# E.I. 77B (Cont'd)

dewar with a stirring device to provide continuous liquid/gas orientation. This will enable specimen immersion and will also prevent venting liquid from the dewar. The stirring action, however, will increase the boil-off rate of the  $\text{LN}_2$ . The following properties were based upon the use of a Linde cryogenic refrigerator, Model LR-21, modified for use in null gravity.

## Weight:

For 30 days -		
Fixed Hardware	13.6 kg	(30 lb)
$\text{LN}_2$ for 30 Days	16.4 kg	(36 lb)
Total for 30 Days	30 kg	(66 lb)

For 7 days -		
Fixed Hardware	13.6 kg (30 lb)	(same dewar)
$\text{LN}_2$ for 7 Days	8.0 kg	(17.6 lb)
Total for 7 Days	21.6 kg	(47.6 lb)

Dimensions: 40.2 cm Dia.  $\times$  58.4 cm H  
(15.8" Dia.  $\times$  23" H)

Envelope Volume: 74.1  $\text{dm}^3$  (2.62  $\text{ft}^3$ )

Power: 10 watts, 28 volt d.c.

Heat Rejection: About 7 watts to cabin air (accounts for approximate heat absorbed by  $\text{LN}_2$ )

Data Management: TBD. Monitor several parameters at low rates.

Location: Adjacent to Low Temperature Freezer  
(E.I. 81, E.U. 4)

Interfaces: Vent  $\text{N}_2$  to Low Temperature Freezer at an average rate of 0.5 kg/day (1.1 lb/day).

Operations: Load and vent  $\text{LN}_2$  during launch sequence. Average  $\text{N}_2$  venting during mission will be 0.5 kg/day. Safety precaution must be taken to preclude overpressurization and catastrophic failure.

E.I. 77B (Cont'd)

Development Time: 30 months

Reference

Integrated Medical and Behavioral Laboratory Measurement System, Final Report for Phase B-4, Volume IV, Book Two, Report No. LMSC-A980308, Lockheed Missiles and Space Co., Sunnyvale, CA, 14 December 1970.

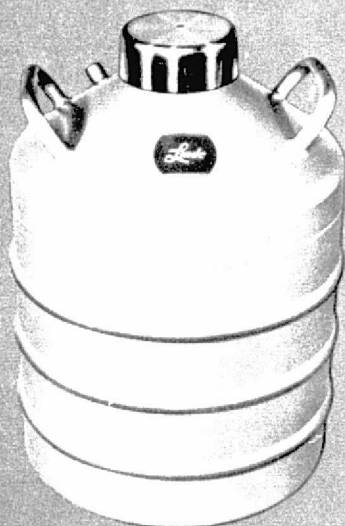
## CRYOGENIC REFRIGERATORS



LR-10



LR-17



LR-21



LR-30

## LR-10

Height	20-5/8"
Diameter	10-1/4"
Weight:	
Empty	11 lbs.
Full	30 lbs.
Necktube Diameter	2"
Maximum LN <sub>2</sub> Capacity	10.4 liters
Ampul Capacity	480 (0.5cc)
(with canisters)	336 (1.0cc)
	252 (1.2cc)
	1380 straws
	(230 medium straws/canister)
Static Evaporation Rate	0.35 liter/day
Static Holding Time	30 days
Warranty	2 years
Part Number	0108-0C06

## LR-17

Height	21-1/8"
Diameter	13-3/4"
Weight:	
Empty	19 lbs.
Full	50 lbs.
Necktube Diameter	2"
Maximum LN <sub>2</sub> Capacity	17.4 liters
Ampul Capacity	480 (0.5cc)
(with canisters)	336 (1.0cc)
	252 (1.2cc)
	1380 straws
	(230 medium straws/canister)
Static Evaporation Rate	0.36 liter/day
Static Holding Time	48 days
Warranty	2 years
Part Number	0177-0C00

## LR-21

Height	23"
Diameter	15-13/16"
Weight:	
Empty	23 lbs.
Full	59 lbs.
Necktube Diameter	2"
Maximum LN <sub>2</sub> Capacity	20 liters
Ampul Capacity	480 (0.5cc)
(with canisters)	336 (1.0cc)
	252 (1.2cc)
	1380 straws
	(230 medium straws/canister)
Static Evaporation Rate	0.22 liter/day
Static Holding Time	90 days
Warranty	2 years
Part Number	0210-0C00

## LR-30

Height	23-7/8"
Diameter	17-3/4"
Weight:	
Empty	33 lbs.
Full	90 lbs.
Necktube Diameter	4-11/16"
Maximum LN <sub>2</sub> Capacity	31.8 liters
Ampul Capacity	3936 (0.5cc)
(with 6 canisters)	2304 (1.0cc)
	1728 (1.2cc)
Ampul Capacity	3360 (0.5cc)
(with 10 canisters)	1840 (1.0cc)
	1380 (1.2cc)
	7000 straws
	9900 straws
	(1650 medium straws/canister)
Static Evaporation Rate	0.58 liter/day
Static Holding Time	55 days
Warranty	2 years
Part Number	0307-0C06

E.I. 80 FREEZER, GENERAL  
(E.U. 4 - Preparation & Preservation Unit)

Purpose

Storage of serum, plasma, specimens, biochemicals, and organisms.

Requirements

Temperature: 244 to 255°K (-29 to -18°C, or -20 to 0°F)

Refrigerated Volume: 28.3 dm<sup>3</sup> (1 ft<sup>3</sup>)

Hardware Status

Rating: SRT

Freezers were used aboard Skylab but their design would not be suitable for the life sciences laboratories aboard the STS/Spacelab. The Skylab freezers utilized a special low temperature space radiator containing Coolanol 15, a heat storage device, pumps, etc. The freezer cold boxes were cooled to 244°K (-29°C, -20°F) by pumping the radiator fluid through tubing integral with the walls of the boxes. The system was very heavy and imposed an orientation requirement on the Skylab. These aspects were not serious drawbacks for Skylab because (1) it was not severely weight-limited, and (2) it was inertially (solar) oriented. However, aboard the STS/Spacelab, weight is important and other payloads besides life sciences may dictate variable pointing requirements. Thus, it appears that a space radiator type of freezer can be ruled out.

An Advanced Refrigeration System Study Contract is currently being funded by NASA/MSFC. It is for the "definition of a refrigerator/freezer system for Space-lab use which is not vehicle orientation dependent". The contract will include the definition of a freezer similar to the general freezer needed for the life sciences laboratories. Thus, actual definition of the general freezer will not be available until this study is completed. The study will probably consider thermoelectric freezers, vapor compression freezers, and the use of cryogenics. For purposes of this study, a thermoelectric freezer was assumed for use.

Technical Description

A preliminary analysis for this freezer was conducted based on information in the following booklet published by Borg-Warner Corp.;

Boesen, G. F., Phetteplace, C. J., and Ybarrondo, L. J., The Where and the Why of Cooling Thermoelectrically, Borg-Warner Corp., Des Plaines, Illinois, 1967.

For a  $28.3 \text{ dm}^3$  ( $1 \text{ ft}^3$ ) cold box, well insulated with 5.1 cm (2 inch) of glass wool or foam-type insulation ( $k = 0.02 \text{ Btu/hr-ft-}^\circ\text{F}$ ), the heat load into the box was calculated at 5 watts, including heat transfer through seals, flanges, etc. Using a contingency factors of 2 to account for miscellaneous heat leaks results in a maximum steady heat loss of 10 watts. In order to minimize the power requirements of the thermoelectric cooling modules, the use of both cold plates to cool the hot junctions of the modules and vacuum insulation to maximize the efficiency of the modules were assumed.

To obtain liquid coolant for experiment use in the Spacelab, the experiment heat exchanger must be used (Ref. Spacelab Payload Accommodation Handbook, ESRO/NASA, May 1975). The experiment heat exchanger can be plumbed so that it receives water coolant at  $291^\circ\text{K}$  ( $18^\circ\text{C}$ ,  $64.4^\circ\text{F}$ ). It was assumed in this case that liquid coolant from this heat exchanger could be made available to the thermoelectric cooling module of the freezer at  $297^\circ$  ( $24^\circ\text{C}$ ,  $75.2^\circ\text{F}$ ). This results in a maximum thermoelectric module temperature difference  $\Delta T$  of  $297^\circ\text{K} - 244^\circ\text{K} = 53^\circ\text{K}$  ( $53^\circ\text{C}$ ,  $95.4^\circ\text{F}$ ). At this temperature difference, Borg-Warner reports a coefficient of performance of about 0.15, which results in a steady state freezer input power of 66.7 watts. Assuming a duty cycle of 8 hours on-time per day gives a value of 200 watts while the freezer is on. This would result in a total maximum cooling rate for the thermoelectric unit of 30 watts ( $120 \text{ Btu/hr}$ ). These values are preliminary in nature and are used herein to establish weight and power values for purposes of preliminary life sciences laboratory definition. Freezer properties should be updated as the results of the Advanced Refrigeration System Study become available. (Contracting Officer's Representative is Jim Moses, NASA/MSFC, Tel. No. 205/453-4474.)

The following is a summary of the estimated properties of the general freezer:

Weight:	15 kg (33 lb)
Dimensions:	28 cm W $\times$ 43 cm H $\times$ 51 cm D (11" $\times$ 17" $\times$ 20")
Envelope Volume:	$61.4 \text{ dm}^3$ ( $2.17 \text{ ft}^3$ )
Power:	200 watts (when on) 28 volt d.c.
Duty Cycle:	8 hours/day
Heat Rejection:	200 watts maximum, 67 watts average. Heat rejected to an experiment provided coolant loop (E.I. 51F) which rejects heat to the Spacelab provided experiment heat exchanger. The experiment heat exchanger must be located upstream of the Spacelab avionics heat exchanger, see Spacelab Payload Accommodation Handbook.

E.I. 80 FREEZER, GENERAL (Cont'd)

Coolant Temperature = 297°K (24°C, 75°F)

Location: It would be desirable but not necessary to locate the freezer close to the Spacelab experiment heat exchanger.

Data Management: Estimated monitoring requirements are:

3 thermocouples once every 10 minutes

1 amperage measurement once every 10 minutes.

Development Time: 30 months

E.I. 81 FREEZER, LOW TEMPERATURE  
(E.U. 4 - Preparation & Preservation Unit)

Purpose

This unit provides storage for some specimens (in particular blood samples) which are partially destroyed at usual freezer storage temperatures of  $-20^{\circ}\text{C}$ .

Requirements

Estimated requirements are:

Temperature:	$203^{\circ}\text{K}$ ( $-70^{\circ}\text{C}$ )
Storage Volume:	Approx. $7\text{ dm}^3$ ( $0.25\text{ ft}^3$ )

Hardware Status

Rating: SRT

No freezers with a  $-70^{\circ}\text{C}$  temperature capability have been flown in spacecraft, and the development of such a freezer may present a number of problems. Thermoelectric freezers are commercially available but consume a large amount of electric power. A commercially available unit called an Electronic Cryo-Bath (available through the Cole Parmer Instrument Co.) contains an 80 cc cold chamber. Its power supply consumes 185 watts, providing a temperature of about  $218^{\circ}\text{K}$  ( $-55^{\circ}\text{C}$ ,  $67^{\circ}\text{F}$ ). To increase the cold chamber volume to  $7\text{ dm}^3$  and reduce the temperature to  $203^{\circ}\text{K}$  ( $-70^{\circ}\text{C}$ ,  $-94^{\circ}\text{F}$ ) would require a substantial increase in power. Preliminary estimates place the power required on the order of 2 kw.

Lower power consuming vapor compression units are available for temperatures down to  $-70^{\circ}\text{C}$ , but past studies on vapor compression units have not recommended their use because of the gas/liquid management problems in null-gravity. Use of cryogenics might be the simplest way to obtain such low temperatures for short missions.

Technical Description

In view of the large power requirement of a thermoelectric low temperature freezer, a cryogenic unit was assumed for purposes of preliminary life sciences laboratory definition. It was further assumed that the low temperature freezer would operate in conjunction with the cryogenic freezer, taking the cold gas from the cryogenic freezer and using it to cool the walls of the low temperature freezer. The  $\text{N}_2$  used in these freezers could be vented into the cabin to help make up for Spacelab atmospheric leakage.

## E.I. 81 FREEZER, LOW TEMPERATURE (Cont'd)

The design of an integrated low temperature and cryogenic freezer will require a comprehensive design program. A cryogenically cooled freezer will be studied as part of the Advanced Refrigeration System Study currently being funded by NASA/MSTC. Thus, information pertinent to the low temperature freezer will be forthcoming from that study. For purposes of this study, the following properties were estimated for a gas cooled low temperature freezer:

Weight:	8 kg (17.6 lb)
Dimensions:	28 cm W × 34 cm H × 32 cm D (11" × 13.4" × 12.6")
Envelope Volume:	30.5 dm <sup>3</sup> (1.08 ft <sup>3</sup> )
Power:	10 watts (controller) 28 volt d.c.
Heat Rejection:	10 watts to cabin air (negative heat rejection due to cryogen is accounted for in cryogenic freezer (4/77B).
Data Management:	Monitor 2 thermocouples each at about once every 10 minutes. Temperature range = 123°K to 233°K (-150°C to -50°C, -238°F to -58°F)
Location:	Must be located adjacent to cryogenic freezer
Interfaces:	See cryogenic freezer for N <sub>2</sub> introduction into cabin.
Operations:	N <sub>2</sub> venting during launch and landing. Load LN <sub>2</sub> during launch sequence.

Development Time: 30 months

## E.I. 83 FRIG. (REFRIGERATOR)

(E.U. 4 - Preparation & Preservation Unit)

### Purpose

To store perishables to be used in the experiments and specimens taken during the experiments for subsequent ground analysis. This includes biological and chemical materials applicable to biomedical, biological, and life support and protective system experiments.

### Requirements

Temperature - 275 to 277°K (35 to 40°F). An internal volume of 57 dm<sup>3</sup> (2 ft<sup>3</sup>) was used for this study. It was assumed that more than one unit could be used if the required volume exceeded this value.

### Hardware Status

Rating: SRT

A refrigerator is currently being studied as a part of the Advanced Refrigeration System Study, being funded by NASA/MSFC (Contracting Officer's Representative is Jim Moses, Tel. No. 205/453-4474). The study is for the "definition of a refrigerator freezer system for Spacelab use which is not vehicle orientation dependent". This contract will include the definition of a refrigerator with a 57 dm<sup>3</sup> (2 ft<sup>3</sup>) storage capacity, a cooling rate of 29 to 59 watts (100 to 200 Btu/hr), and power requirement goal of 200 watts or less. Thus, this study will result in more details on a refrigerator applicable to the life sciences laboratories. The study will consider at least thermoelectric and vapor compression refrigeration units.

### Technical Description

Based on preliminary calculations on a thermoelectric refrigerator, the following properties were used for the life sciences laboratory refrigerator:

Weight:	18 kg (40 lb)
Dimensions:	
External	44.5 cm W × 53.3 cm H × 50.8 cm D (17.5" W × 21" H × 20" D)
Internal	36.8 cm W × 45.7 cm H × 33.7 cm D (14.5" W × 18" H × 13.25" D)

E.I. 83 (Cont'd)

Volume:

External Envelope	120 dm <sup>3</sup> (4.24 ft <sup>3</sup> )
Internal	56.7 dm <sup>3</sup> (2 ft <sup>3</sup> )

Power: 50 watts, 28 volt d.c., duty cycle is 8 hours/day

Heat Rejection: 50 watts when on, to cabin air

Data Management: Monitor 3 thermocouples, once every 10 minutes and one amperage once every 10 minutes

Location: Spacelab rack mounted

Interfaces: EPS, CDMS, cooling air

Development Time: 30 months

E.I. 87 GAS ANALYZER, INFRARED  
(E.U. 5 Biochemical and Biophysical Analysis Unit.)

Purpose

To measure individual gas constituents in gas mixtures.

Requirements

This analyzer is intended to be a small infrared unit with the capability to continuously monitor several specific gases such as CO<sub>2</sub> and CO. By slight modifications and recalibration of the basic analyzer prior to individual flights, several of a variety of gases can be measured depending upon specific experiment requirements.

The sensitivity required for various gases will depend upon the specific experiments. Some experiments will require trace gases to be monitored in the low ppm range. Thus, a highly sensitive IR analyzer would be required.

Hardware Status

Several IR analyzers are commercially available, including the LIRA IR Analyzer and the IR Industries analyzer for which several catalog sheets are attached. The IR Industries Series 700 analyzer includes readout meters but can be supplied with output voltage devices for connection to other displays.

Technical Description

The weight volume and power requirements of the IR Industries Series 700 analyzer were used as a basis of the flight equipment properties. These are:

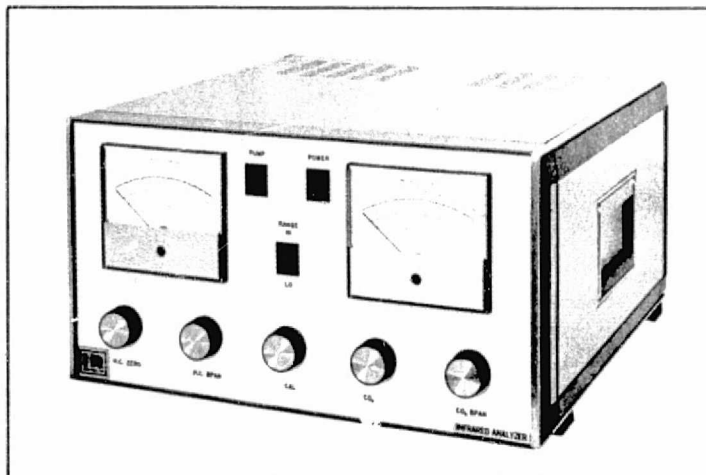
Weight	11.3 kg (25 lb)
Size	4.32 x 4.32 x 2.29 dm (17 x 17 x 9 inches)
Volume	42.6 dm <sup>3</sup> (1.51 ft <sup>3</sup> )
Power	50 watts

Development Time: 9 months

# PROCESS INFRARED ANALYZER

## NON-DISPERSIVE

- MULTIPLE GAS MONITORING\*  
WITH SINGLE INSTRUMENT
- SOLID STATE ELECTRONICS
- DUAL PATH—SEQUENTIAL  
BEAM
- INTERNAL OR SPAN GAS  
CALIBRATION
- FAST WARM-UP—15 MINUTES



**SERIES 700**

### DESCRIPTION

The Infrared Industries NDIR gas analyzer measures the concentration of gas constituents in a gas mixture by optically sensing the attenuated radiant energy from an infrared source. This measurement is done rapidly, accurately and without contamination or change in the gas being measured. High instrument stability assures maximum user convenience.

Accuracy of the measuring system is assured by precision manufacturing techniques. Infrared is uniquely suited to provide the three primary disciplines required to produce and service these instruments: precision mirrors and filters, detectors specifically designed for this application, and electronics for the data processing function.

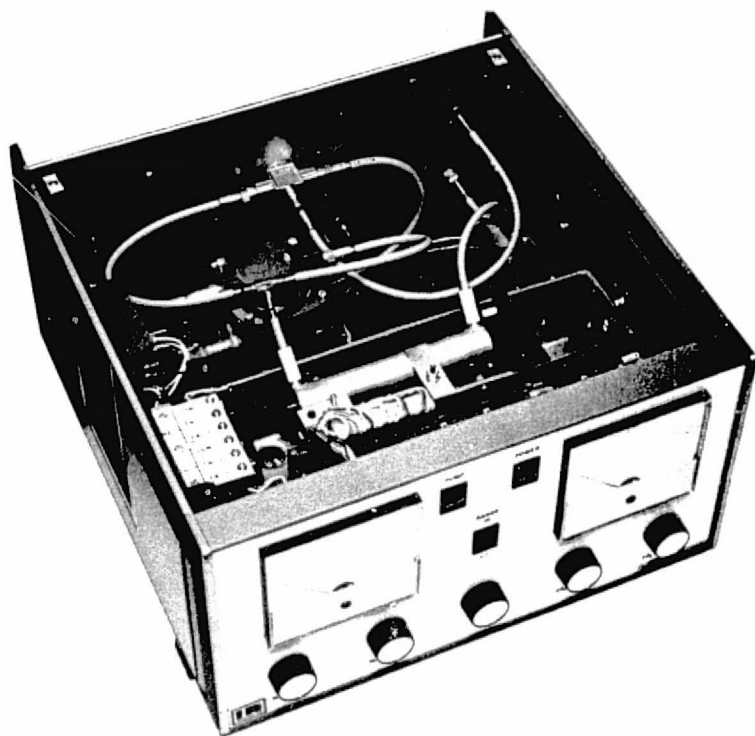
Model 700 series is a simple self-contained instrument. The primary outputs are meter displays of the individual gas concentrations. The unit can be supplied with an output voltage suitable for recording systems or can be connected to other devices for linearizing, digitizing, encoding, or numerical display.

### SPECIFICATIONS

**CONCENTRATION RANGE:** see various model specs (back page)  
**ACCURACY:** 1% of full scale  
**REPEATABILITY:**  $\pm 0.5\%$  of full scale  
**SENSITIVITY:** 0.2% of full scale  
**RESPONSE TIME:** 5 seconds with 1CFH sample flow

**OUTPUTS:** 0-100mV  
**AMBIENT TEMPERATURE:** 32°F to 110°F  
**RELATIVE HUMIDITY:** 0-99%  
**POWER REQUIREMENTS:** 115V, 60Hz, 50 watts  
**ZERO DRIFT:** Less than 2%/24 hr  
**SIZE AND WEIGHT:** 17 x 17 x 9, 25 lbs.

\*CONSULT FACTORY FOR AVAILABLE COMBINATIONS



## CONSTITUENT GAS SENSITIVITY

RANGE	PARAMETER
0-1 % 0-5 % 0-10 %	CO
0-500 ppm 0-1000 ppm 0-2500 ppm 0-2 % 0-5 % 0-15 %	CO <sub>2</sub>
0-500 ppm 0-1000 ppm 0-2000 ppm 0-10,000 ppm 0-5 % 0-10 %	HC Hexane Equiv.
0-10,000 ppm 0-2 % 0-10 %	NO
0-10,000 ppm 0-5 % 0-10 %	SO <sub>2</sub>

## OPTIONAL FEATURES

**Linear Output:** Integration of data is frequently required in batch or process applications; however, since all IR Analyzers behave according to Beer's Law, their output is non-linear as a function of concentration. Non-linear signals are difficult to handle accurately in process applications. To permit accurate data integration, a circuit linearizer is available which plugs directly into the instrument.

**Optical Calibration:** Span gas is eliminated for most applications, thus, lowering the cost of operation significantly. No need to worry about cylinder gas variances or erroneous cylinder labeling.

**Corrosion Resistant:** Simplifies the job of applying and maintaining the Model 700 on process streams. Materials in contact with sample are 316 stainless steel and Teflon.

## DESIGNED FOR APPLICATIONS IN:

**Chemical and Petroleum**

Carbon Dioxide: Ethylene Oxide Manufacture, Phthalic Anhydride Manufacture, Ammonia Manufacture, Producer Gas Monitor, Nitrogen Generation.

Acetylene: Acetylene Manufacture, Acrylonitrile Manufacture, Vinyl Chloride Manufacture.

Sulfur Dioxide: Sulfuric Acid Stack Gas.

**Food and Agriculture**

Carbon Dioxide and Water Vapor: Blanketing of Perishables  
Photosynthesis Studies

**Aerospace and Oceanography**

Carbon Dioxide,  
Carbon Monoxide  
and Water Vapor: Diving and Space Chambers

**Medical**

Carbon Dioxide: Respiratory Studies.  
Carbon Monoxide: Clinical Pulmonary Diffusing Capacity.  
Various Anesthetics: Anesthesia.

**Metals and Ceramics**

Carbon Dioxide: Producer Gas Monitor, Steel Converting, Cement Manufacture, Soaking Pit, Heat Treating.

Carbon Monoxide: Inert Gas Generation, Producer Gas Monitor, Rotary Kiln Roasting, Tin Plant Annealing, Steel Converting, Aluminum Powder Processing, Porcelain Tunnel Kilns.

Water Vapor: Heat Treating, Hydrogen Brazing, Nickel and Chrome Plating.

Sulfur Dioxide: Flash Smelting.

E.I. 91 GAS ANALYZER, MASS SPECTROMETER  
(E.U. 5 - Biochemical & Biophysical Analysis Unit)

Purpose

To measure concentrations of individual gases in gas mixtures.

Requirements

Requirements will depend upon the specific experimental equipment being tested. Common gases which require monitoring include  $O_2$ ,  $N_2$ ,  $H_2$ ,  $CO_2$ ,  $CO$ ,  $CH_4$ ,  $H_2O$ , and  $NH_3$ . In addition, atmospheric trace constituents will probably need to be measured. The mass spectrometer may be combined with a gas chromatograph to separate components such as  $CO$  and  $N_2$  which have the same mass number. The mass spectrometer would provide the sensitivity to measure trace gases in the parts-per-million range.

Hardware Status

Rating: New Development

A number of mass spectrometers for spaceflight and aircraft applications have been built by Perkin Elmer, Aerospace Division. These include one for the Skylab metabolic analyzer and one for the Viking Mars probe. The latter operates in conjunction with the gas chromatograph and is referred to as the Viking Gas Chromatograph/Mass Spectrometer (GCMS). It will measure trace gases in the 0.5 to 50 ppm range. The unit weighs 20.4 kg (45 lb) and requires up to 144 watts, the maximum power being required during pyrolysis of soil from the Mars surface. Also, a Perkin-Elmer mass spectrometer system is currently being developed for NASA/JSC for use on the Shuttle Orbiter. It is called the Flight Trace Contaminant Sensor, and will measure the major atmospheric constituents as well as trace gases. Such a unit may be usable for the Life Sciences Laboratory. The specifications of the mass spectrometer used on Viking, which is similar to the unit planned for use on the Shuttle Orbiter, are attached to the end of this writeup.

Technical Description

Estimated properties of a Perkin-Elmer mass spectrometer integrated with several gas chromatograph columns for preprocessing gas samples are given below. These data are very tentative but can be better defined as development of the Shuttle Flight Trace Contaminant Sensor progresses.

E.I. 91 (Cont'd)

Weight: 25 kg (55 lb)

Volume:  $20 \text{ dm}^3$  (.71  $\text{ft}^3$ )

Power: 50 watts, 28 volt d.c.

Heat Rejection: 50 watts

Data Management: The preliminary design concept for the Shuttle system includes a direct readout device for 10 gases (to be determined). The remaining constituents will be analyzed by use of a digital computer program. Whether this processing will be done on board or on the ground is yet to be determined.

Location: Can be placed in Spacelab rack.

Interfaces: CDMS. Other likely interfacing EIs include the holding units, Ventilation Unit (E.I. 182P, E.U. 42), Vertebrate ECS (E.I. 182R, E.U. 42), LSS Test Console (E.I. 115F, E.U. 80), Glove Box (E.I. 96, E.U. 4), and Work and Surgical Bench (E.I. 188, E.U. 4), Vacuum Manifold (E.I. 118I, E.U. 3) and Plumbing (E.I. 141A, E.U. 3).

Operations: tbd

Development Time: 24 months

## Perkin Elmer Mass Spectrometer Specifications

### Purpose

To measure concentrations of individual gases in gas mixtures.

### Hardware Status

Qualified for Viking 75 GCMS assembly.

### Technical Discription

Self contained double focusing instrument of the Nier-Johnson,  $90^\circ/90^\circ$  type.

### Mass Scan Range

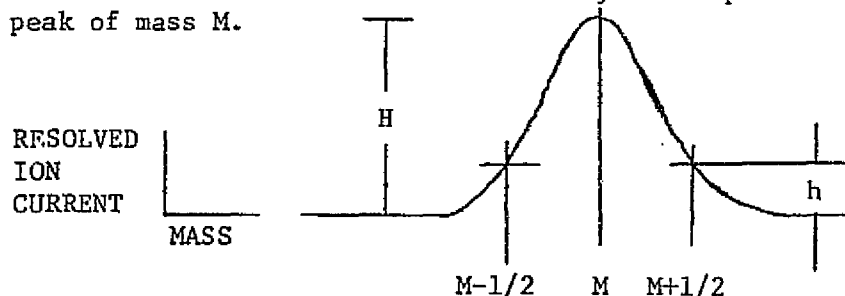
The Mass Spectrometer (MS) shall have a nominal mass scan range of 11.5 to 223 amu. The starting point limits shall be defined between 11 and 12 amu and the end point limits shall be 202 to 245 amu inclusive.

### Mass Scan Frequency

The MS shall be scanned continuously during analysis. The scan time shall be less than 11 seconds.

### Resolution

The MS resolution can be determined by the amplitude distribution of a single peak of mass M.



For  $M \sim 200$  amu, the ratio of the current maximum,  $H$ , to the current at mass position  $M + 1/2$  shall equal or exceed 10. For decreasing mass numbers the ratio shall continuously increase such that for MS 140 amu the ratio shall equal or exceed 20.

### Resolved Ion Current Dynamic Range

The dynamic range of the MS, for resolved ion current peaks, shall be seven (7) decades ( $5 \times 10^{-13}\text{A}$  to  $10^{-6}\text{A}$  at the output of the EMT). For a peak signal of  $10^{-11}\text{A}$  from the EMT, the signal to RMS noise ratio shall be greater than or equal to three (3). The noise shall be considered as referred to the input of the electrometer. The input offset shall not exceed  $3 \times 10^{-13}\text{A}$  measured at Acceptance Test under laboratory ambient temperature ( $23^\circ\text{C}$ ) conditions.

### Sensitivity for Mass Resolved Ions

Sensitivity is defined in terms of MS output per unit gas flow into the MS. For ionizing electrons with energy 70 eV the MS shall have a sensitivity exceeding  $3.0 \times 10^{-4}$  A/torr cc/s for the mass 28 peak of nitrogen. A nitrogen flow of  $9.0 \times 10^{-7}$  /torr cc/s into the MS shall produce an output current equal to or greater than  $2.3 \times 10^{-10}$  A with a root-mean square noise amplitude that is less than 8% of this current and a signal bandwidth of 5-155 Hz. The stated sensitivities shall apply to the operation of the source under a continuous scanning mode with the filament giving highest sensitivity. The sensitivity, when operating with the less sensitive filament, shall not be less than 10% of the stated sensitivity.

### Sensitivity for Total Ion Current

The total ion current monitor system shall have a sensitivity exceeding  $5.0 \times 10^{-7}$  A/torr cc/s for nitrogen in a continuous scanning mode using 70 eV electron ionizing energy and the most sensitive filament at the scan voltage corresponding to the mass 28 peak. The variation of TIC sensitivity during one scan period shall not be less than 20% of the peak sensitivity. The TIC sensitivity for the less sensitive filament shall not be less than 10% of the sensitivity stated for the more sensitive filament.

### Accuracy Requirements

- A. Mass Number. The allowed percentage change in the mass maker voltage measurement shall not exceed  $\pm 0.125\%$  of value between two immediately successive scans. Furthermore, in any single scan the mass maker voltage  $V_2$ , corresponding to mass  $m_2$ , cannot vary from the value given by the expression  $(m_1/m_2)V_1$  by more than  $\pm 0.125\%$  of value for  $2 \geq m_1/m_2 \geq 0.5$ .
- B. Spectrum Reproducibility. The spectrum amplitude reproducibility for two immediately successive scans shall be such that corresponding ion current peaks shall not vary by more than 10% for currents exceeding  $10^{-9}$  amps out of the electron multiplier.

### Operating Conditions

- A. Ion Source Filaments. The ion source shall be capable of operating upon command with either of two filaments.
- B. Ionizing Electron Energy. The ion source shall be capable of operating with ionizing electron energies of either 70 eV or 42.5 eV.
- C. Ion Source Temperature. When operating in the organic analysis mode, the indicated ion source temperature shall be in the range of 200 to 225°C. Short term stability shall be  $\pm 5^\circ\text{C}$  over 15 seconds. For long term stability drift shall be less than  $15^\circ\text{C}$  per hour.
- D. Resolved Ion Current Gain. The RIC detection circuits shall be capable, upon command, of operating at any one of three gains. These three gains shall be set as follows:
  - (1) Nominal Gain. With 15.2 torr of  $\text{CO}_2$  against the molecular leak, the output of the multiplier shall be  $10^{-6}$  A at the m/e 44 peak.

E.I. 91 (Cont'd)

- (2) Maximum Gain. 100 times nominal or the value determined by the safe limit of the EMT supply, whichever is less, but in no case less than 10 times nominal.
- (3) Intermediate Gain. Nominal X Maximum.Nominal.

The variation in these ratios will not exceed  $\pm 10\%$  as measured under the same conditions.

Weight: 20 lb  
Volume: 955 cubic inches  
Power: 16 watts

E.I.93 GAS ANALYZER, RH (HUMIDITY SENSOR)  
(EU 5 Biochemical and Biophysical Analysis Unit)

Purpose

To monitor water vapor content, generally in atmospheric air.

Requirements

Range: tbd.

Hardware Status

Rating: Modification

Available laboratory devices include those which utilize psychrometers, hygroscopic membranes, and dew point detection methods. Any of these methods could be readily adapted to the biolaboratory application.

The sensing device used during the Apollo program is presented below (ref. Environmental Control and Life Support 1973 Component Specifications, BSM Definition Study, Contract NAS9-6796, Report 18-4-009, General Dynamics Convair, San Diego, October 1967, pg. 76).

Technical Description

The sensing device consists of an oxidized aluminum strip covered by a thin layer of gold. The aluminum oxide acts as a dielectric between the gold and aluminum electrodes and its conductivity varies with the surrounding water vapor partial pressure.

Moisture range:	0.001 $\mu\text{g}$ to 20,000 $\mu\text{g H}_2\text{O/liter}$ (0 to 98% RH at 70° F)
Temperature range:	-110° C to +60° C
Output impedance:	200 ohms
Output voltage:	0-100 mv
Power:	6 watts
Input voltage:	110/220 @ 48 to 63 cps
Weight:	5.2 kg (11.5 lbs) (sensor plus signal conditioner)
Envelope:	31.4 x 25.7 x 16.5 cm (12-3/8 x 10-1/8 x 6-1/2 in.)

E.I. 93 GAS ANALYZER, RH (HUMIDITY SENSOR) (Cont)

Volume:  $0.013 \text{ m}^3$  ( $0.47 \text{ ft}^3$ )

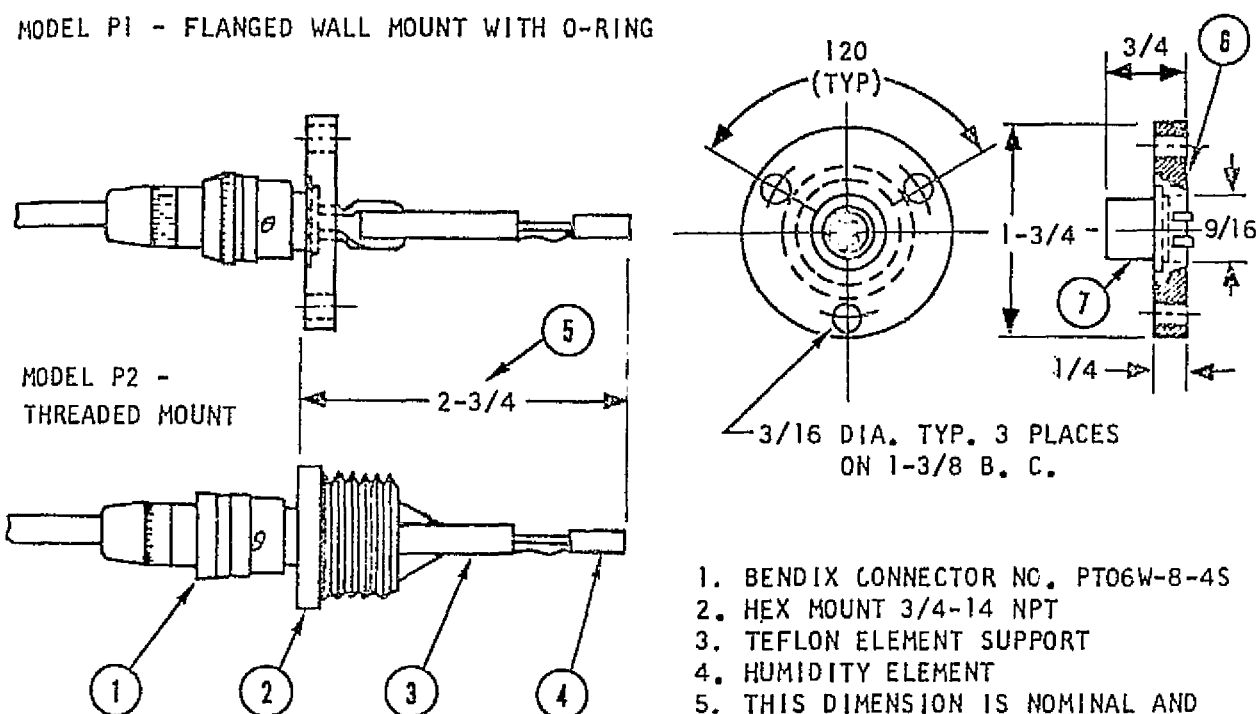
Sensor size: Approx. 2.5 cm dia. x 10 cm long (~ 1" dia. x 4" long)

Development Time: 6 months

# E.I. 93 GAS ANALYZER, RH (HUMIDITY SENSOR) (Cont)

## STANDARD PROBE MOUNT ASSEMBLIES

### MODEL P1 - FLANGED WALL MOUNT WITH O-RING



### NOTE:

1. CLEARANCE HOLE 9/16 DIA NEEDED FOR MODEL -1
2. THREADED RECEIVING HOLE FOR 3/4-14NPT NEEDED FOR MODEL -2

1. BENDIX CONNECTOR NO. PT06W-8-4S
2. HEX MOUNT 3/4-14 NPT
3. TEFLON ELEMENT SUPPORT
4. HUMIDITY ELEMENT
5. THIS DIMENSION IS NOMINAL AND WILL VARY  $\pm 1/8$
6. O-RING CIRCLE O. D. = 1-1/8
7. BENDIX CONNECTOR NO. PTIH-8-4P

## DEW-POINT SENSOR

E.I. 93A GAS SUPPLIES  
(E.U. 3 Life Sciences Experiment Support Unit.)

Purpose

To provide gases for various experiment uses.

Requirements

Various gases will be required in experiments for purposes of pressurization, chemical reactions, sterilization purging, cooling, etc. Some of the gases which may be needed include O<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>, NH<sub>3</sub>, He, Air, CO<sub>2</sub>, CO, CH<sub>4</sub>, ethylene oxide. The quantities required will depend upon the experiments. However, for preliminary design purposes, a 13,800 kN/m<sup>2</sup> (2000 psia) vessel of approximately 15 dm<sup>3</sup> (0.53 ft<sup>3</sup>) capacity was assumed.

Hardware Status

Rating: Modification

High pressure gas vessels have been used in numerous past space flights. Thus, applicable designs or hardware should be available.

Technical Description

To determine the approximate weight and volume characteristics of the gas supply vessels two vessels assumed to hold 15 dm<sup>3</sup> (0.53 ft<sup>3</sup>) of different gases were used. Each would hold 2.7 kg (6 lb) of O<sub>2</sub> or 2.4 kg (5.3 lb) of N<sub>2</sub>. These gases were assumed for purposes of estimating weights. The vessel weights (empty) were estimated to be 3.2 kg (7.1 lb) each. The total envelope volume of each vessel was assumed to be 18 dm<sup>3</sup> (0.64 ft<sup>3</sup>) to account for lines, valves, and regulators. A summary of the estimated properties of these two vessels is given below along with the average weight and volume to be used for a single vessel.

	O <sub>2</sub>	N <sub>2</sub>
Weight empty kg (lb)	3.2 (7.1)	3.2 (7.1)
Gas, weight kg (lb)	2.7 (6)	2.4 (5.3)
Total weight kg(lb)	5.9 (13.1)	5.6 (12.4)
	5.75 (12.75) Avg.	
Volume dm <sup>3</sup> (ft <sup>3</sup> )	18 (.64)	18 (.64)
	18(.64) Avg.	
Vessel length (ea)	4.7 dm (1.5 ft)	
Vessel diameter (spherical ends)	2.2 dm (0.72 ft)	
Power	0	

Development Time: 6 months.

E.I. 96 GLOVE BOX, PORTABLE  
(E.U. 4 Preparation and Preservation Unit.)

Purpose

To provide an enclosure for various biological procedures on organisms and specimens for the purpose of minimizing contamination of the cabin with foreign gases and particles including bacteria.

Requirements

This glove box should be simple and lightweight. It should be attachable to the organism holding units.

Hardware Status

Rating: Re-design

Commercial glove boxes are available but are too large and heavy for use in the laboratory. Thus, this glove box will have to be custom designed using commercially available components. No complicated design problems are foreseen.

Technical Description

Estimated properties of a portable glove box are:

Weight	4.5 kg (10 lb)
Stowed Volume:	25 dm <sup>3</sup> (0.9 ft <sup>3</sup> )
Deployed Volume:	0.3m <sup>3</sup> (10.6 ft <sup>3</sup> )
Power:	0

Development Time: 12 months

E. I. 96C GLOVE BOX LINERS  
(E.U. 4 Preparation and Preservation Unit.)

Purpose:

A replaceable liner for the glove box to prevent cross-contamination from one glove box operation to the next. It can be removed and disposed of when changing worksites.

Requirements:

Hardware Status:

Rating: Re-design

This item will be developed as an integral part of the Glove Box (EI 96, EU 4).

Technical Description:

Weight:	0.5 kg (1.1 lb)
Volume:	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )
Power:	0 watts

Development Time: 12 months

E.I. 97C HANDWIPES, BETADYNE  
(E.U. 6 - Maintenance, Repair & Fabrication Unit)

Purpose

For cleanup and sterilization of hands and contaminated surfaces.

Requirements

Wipes used on previous spaceflights were assumed to meet the requirements.

Hardware Status

Rating: Space Qualified

Skylab carried biocide wipes which were assumed to be usable.

Technical Description

Approximate properties of the wipes are:

Weight:	0.27 kg (0.60 lb) for 10 wipes
Dimensions:	10 cm × 10 cm × 3 cm (4" × 4" × 1.2") for package of 10 wipes
Volume:	340 cm <sup>3</sup> (0.01 ft <sup>3</sup> )
Power & Heat Rejection:	0

Development Time: None

E.I. 98A HOLDING UNIT CELLS & TISSUES  
(E.U. 60 Cells and Tissues Holding Unit.)

Purpose

To house cells and tissues under specified environmental conditions. This unit is similar to an incubator.

Requirements

This equipment item is essentially the Common Holding Unit (see E.I. 99) except that some unique equipment is needed inside in order to hold the cells and tissues organism containers.

Hardware Status

Rating: SRT

This holding unit is currently the subject of two parallel contracts, each entitled Conceptual Design for a Biological Holding Facility, which are being funded by NASA/MSFC. These contracts were awarded in May 1975 and will result in preliminary designs of the holding units. One prototype for ground based operation has been built by General Dynamics Convair Aerospace. It was used as the basis of the properties given below.

Technical Description

Estimated properties are:

Weight:	23 kg (50 lb)
Volume:	188 dm <sup>3</sup> (6.64 ft <sup>3</sup> )
Power:	50 watts

It should be noted that the weight, power and volume of the Common Holding Unit (EI 99) are included in the above values, and should not be added into the life sciences laboratories as separate items.

Development Time: 36 months

E.I. 98C HOLDING UNIT, INVERTEBRATES  
(E.U. 70, Invertebrate Holding Unit.)

Purpose

To house and provide controlled environmental conditions for invertebrate test organisms.

Requirements

This equipment item is essentially the Common Holding Unit, E.I. 99, except that some unique internal equipment will be required for supporting the invertebrates and related research equipment.

Hardware Status

Rating: SRT

This holding unit is currently the subject of two parallel contracts, each entitled Conceptual Design for a Biological Holding Facility, which are being funded by NASA/MSFC. These contracts were awarded in May 1975 and will result in preliminary designs. One prototype for ground operation and testing has been built by General Dynamics, Convair Aerospace Division. It was used as the basis of the properties presented below.

Technical Description

Estimated properties are:

Weight	23 kg (50 lb)
Volume	188 dm <sup>3</sup> (6.64 ft <sup>3</sup> )
Power	50 watts

It should be noted that the weight, power and volume of the Common Holding Unit (EI 99) are included in the above values, and should not be added into the life sciences laboratories as separate items.

Development Time: 36 months.

E.I. 99 HOLDING UNIT, COMMON  
(E.U. 40 Small Vertebrate Holding Unit.)

Purpose

To house a variety of biological organisms including cells and tissues, invertebrates, plants, and small vertebrates. These holding units provide structural support, environmental control system connections, hermetic isolation, and data management connections for these organisms and the related research.

Requirements

The common holding unit is intended as a basic housing to support a variety of organisms. However, slight modifications are required for the various organisms and experiments. The common holding unit must accommodate 8 small vertebrate cages (E.I. C30A) and other internal equipment peculiar to plant, invertebrate and cell/tissues research. It should be sealable in order to minimize air leakage into or out of the organism compartment, and should also be capable of withstanding a pressure differential of approximately  $3.5 \text{ kN/m}^2$  (0.5 psi) in either direction. It must also be designed to mate with the Glove Box, Portable (EI 96, EU 4).

The common holding unit must incorporate a system for controlling its internal temperature. The temperature range required is estimated to be approximately 283 to 313°K (10 to 40°C or 50 to 104°F) for various organisms.

Hardware Status

Rating: SRT

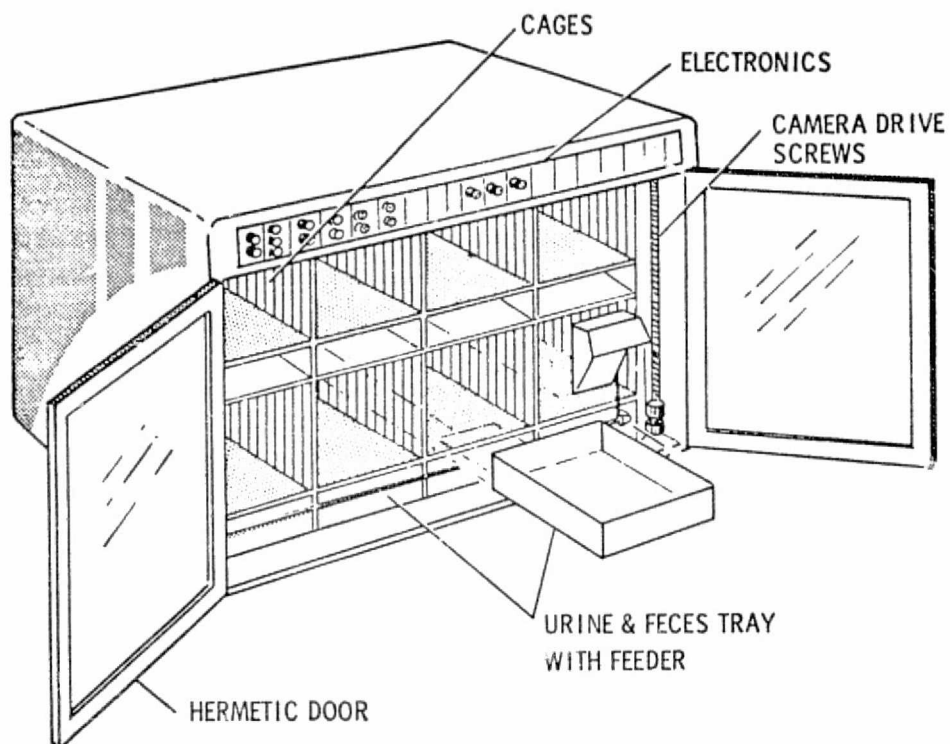
Several prototype holding units have been built by General Dynamics Convair Aerospace for ground testing (see attached sheets). These are similar to those which would be required for the life sciences laboratories. However, a flight qualified unit has yet to be designed and built.

Technical Description

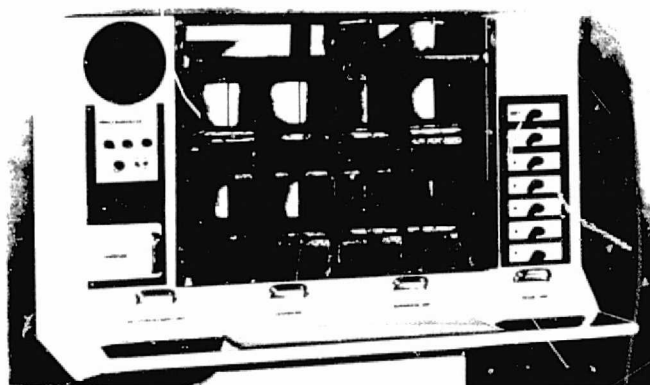
The common holding unit is the basic structure to be used for housing various experiment organisms. The unit is a sealable cabinet with doors for access to the organisms. It is intended to incorporate a system for temperature control of the atmosphere inside the holding unit. The Convair Aerospace unit uses liquid coils integral with the walls of the common holding unit for this purpose. Thus, in flight, the heat transport fluid of the spacecraft could be used to provide either heating or cooling to the common holding unit. The following are estimates for the common holding unit:

Weight:	20.4 kg (45 lb)
Volume:	$188 \text{ dm}^3$ (6.64 ft <sup>3</sup> )
Power:	50 watts (lights)

Development Time: 36 months



Convair Common Holding Unit Concept with Cages for Small Vertebrates



Picture of Common Holding Unit Prototype Built by General Dynamics/Convair

E.I. 101 HOLDING UNIT, PLANTS  
(E.U. 50, Plant Holding Unit.)

Purpose

To hold plants under specified conditions of temperature and humidity and provide light for their growth.

Requirements

Specific requirements have not been determined. General requirements have been discussed for E.I. 99, the Common Holding Unit, which is used as the basic structure of the Plant Holding Unit. Added to the Common Holding Unit are structural support components and a lighting system. The lighting system must include cooling components for the purpose of dissipating the waste heat from the lights.

Hardware Status

Rating: SRT

This holding unit is currently the subject of two parallel contracts, each entitled Conceptual Design for a Biological Holding Facility, which are being funded by NASA/MSFC. These contracts were awarded in May 1975 and will result in preliminary designs of the holding units. One prototype Plant Holding Unit for ground based testing has been built by General Dynamics/Convair. It was used as the basis for the properties presented below.

Technical Description

Estimated properties are:

Weight	25 kg (55 lb)
Volume	188 dm <sup>3</sup> (6.64 ft <sup>3</sup> )
Power	500 watts

It should be noted that the weight, power and volume of the Common Holding Unit (EI 99) are included in the above values, and should not be added into the life sciences laboratories as separate items.

Development Time: 36 months

E.I. 101B HOLDING UNIT, MONKEY POD  
(E.U. 41 - Primate Holding Unit)

Purpose

To provide a housing enclosure for a restrained primate (8-14 kg macaque monkeys) and allow measurements of metabolic, respiratory and cardiovascular function.

Requirements

The monkey pod provides for:

1. Monitoring of the ventilating air stream for  $P_{O_2}$ ,  $P_{CO_2}$ ,  $P_{N_2}$  and  $P_{H_2O}$  to permit continuous metabolic gas-exchange measurements for computation of metabolic energy expenditure.
2. Collection of all feces and urine by entrapment using ashless filter paper. All excreta and filter paper are removed at the end of the experiment period, 1 to 10 days, for chemical analyses.
3. Application of negative pressure to the lower-body of the restrained animal to test cardiovascular competency.
4. Automatic food pellet and drinking water dispensers for quantitative measurement of nutrient intake.

Hardware Status

Rating: New Development.

A fiberglass monkey pod system has been developed by the Environmental Physiology Laboratory of the White Mountain Research Station, University of California, Berkeley, California. This system was used in the NASA/Ames Shuttle Spacelab Concept Verification Test II (CVT II) during the period 15-26 April 1974. Further development by NASA/Ames is expected to bring the monkey pod to flight qualification status.

Technical Description

The monkey pod system consists of a fiberglass pod containing a comfortable restraint couch for the animal. The pod is divided into upper and lower halves. When the monkey is restrained in the couch, a rubber belly-band forms a gas seal between the upper and lower portions of the animal. Separate air streams are maintained in each portion; the upper for respiration and metabolism measurements, and the lower

E.I. 101B (Cont'd)

for waste management. Food and water dispensers are operated ad libitum by the monkey.

Estimated properties of the flight unit are:

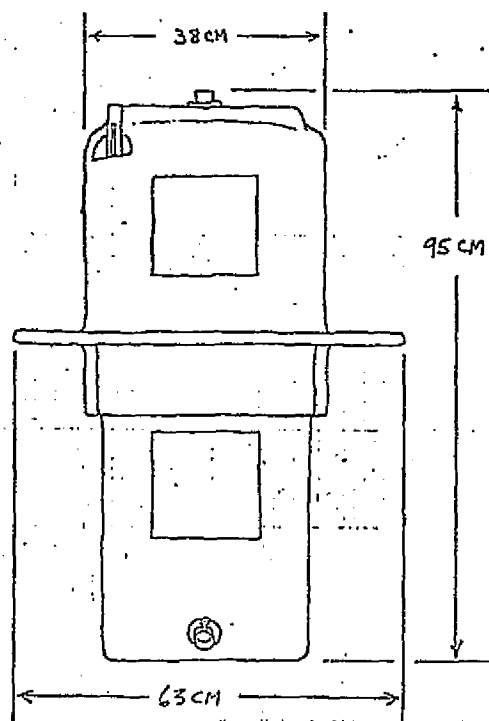
Weight:	53 kg (117 lb)
Envelope Dimensions:	95 cm × 71 cm × 63 cm (37" × 28" × 26")
Envelope Volume:	425 dm <sup>3</sup> (15.0 ft <sup>3</sup> )
Power:	100 watts (on-duty), 30 watts (off-duty)
Food:	200 g/day
Water:	1 kg/day
Ventilation:	Upper pod — 10 liters/min., clean dry air Lower pod — 25 liters/min., clean dry air
Interfaces:	Mass Spectrometer (E.I. 91, E.U. 5) Water Tank (E.I. 174, E.U. 42) Ventilation Unit (E.I. 182P, E.U. 42)

Development Time: 18 months

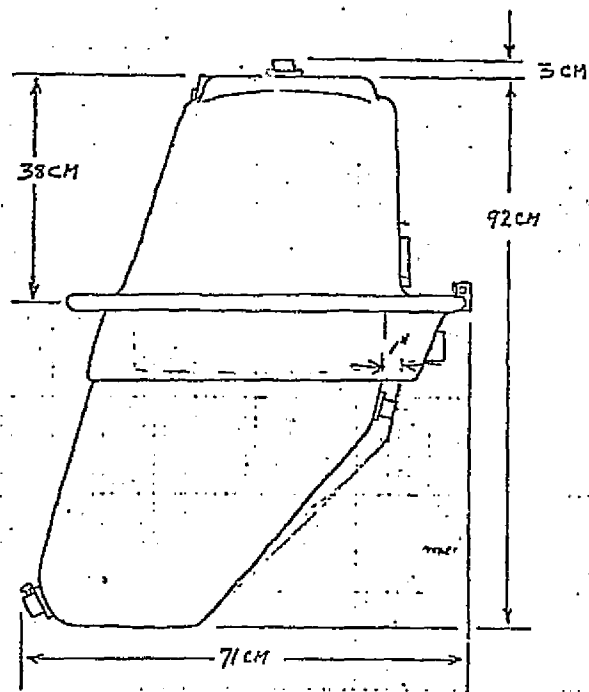
References

1. "A Monkey Metabolism Pod for Space-Fight Weightlessness Studies," N. Pace, et al., L5.7, COSPAR, 1973.
2. "Results from the EPL Monkey-Pod Experiment Conducted as Part of the 1974 NASA/Ames Shuttle CVT-II," D. V. Rahlmann, et al., EPL, Univ. of California, EPL 74-1, June 1974.

E.I. 101B (Cont'd)



Front View



Side View

Environmental Physiology Laboratory  
University of California  
Fiberglass Monkey Pod  
(10-15 Kg Monkey)

E.I. 101C HOLDING UNIT, PRIMATE  
(E.U. 41 - Primate Holding Unit)

Purpose

To provide a housing enclosure for one small primate, characterized by an adult macaque monkey weighing from 5 to 9 kg (12 - 20 lbs). The holding unit, as defined herein, relies on other equipment items (E.I.s 182P or 182R) for ventilation and internal environmental control.

Requirements

The holding unit:

1. Must provide for both restrained and unrestrained primate holding.
2. Must provide for primate feeding and watering. It has been assumed that the holding unit will include all the required food for 7 to 30 day missions (approx. 150 g/day per primate). However, drinking water is included in E.I. 174, E.U. 42, Tank, Vertebrate Water (about 450 g/day per primate).
3. Must include waste collection provisions for approximately 400 g/day of urine and 75 g/day of feces.
4. Must be designed to interface with the ventilation unit (E.I. 182P, E.U. 42) or the vertebrate ECS (E.I. 182R, E.U. 42), the glove box (E.I. 18, E.U. 4), and the various couplers used in conjunction with electrophysiological monitoring.
5. Has been assumed to include psychomotor performance measurement equipment and exercise equipment.
6. Must include provisions for primate retrieval.

Hardware Status

Rating: SRT

This holding unit is currently the subject of two parallel contracts, each entitled Conceptual Design for a Biological Holding Facility, which are being funded by NASA/MSFC. These contracts were awarded in May 1975 and will result in preliminary designs of the primate holding units. For purposes of this study, preliminary estimates were made and are presented below.

## E.I. 101C (Cont'd)

### Technical Description

The major components of the primate holding unit are listed below, along with their estimated weights. Some of this data was based upon the results of the Orbiting Primate Experiment (OPE) study (Reference 1 cited below).

<u>Item</u>	<u>Weight, kg</u>
Holding Unit Enclosure & Structural	23
Waste Collection System (Filter System)	6
Feeding Mechanism & Food for up to 30 Days	16
Ducting & Plumbing	7
Retrieval Net & Handling Equipment	5
Psychomotor & Exercise Equipment	15
Drinking Water Dispensing System	7
Data Management Equipment	12
Animal	7
Miscellaneous Equipment & Contingency	15

Total Weight	113 kg (250 lb)
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Dimensions:	TBD
Envelope Volume:	340 dm <sup>3</sup> (12 ft <sup>3</sup> ) (est. from Ref. 2, below)
Power:	100 watts d.c. (30 watts estimated for off-duty)
Heat Rejection:	100 watts (to air)
Data Management:	tbd
Location:	Should be located adjacent to its ventilation or ECS system.
Interfaces:	(1) Spacelab EPS & CDMS (2) Interchange ventilating air through interconnecting ducting with the ventilation unit (E.I. 182P) or the vertebrate ECS (E.I. 182R).

Development Time: 42 months

### Reference

- 1.Orbiting Primate Experiment for Study of Extended Weightlessness, Final Report, Contract NAS1-6972, NASA CR66520, Lockheed Missiles and Space Co., Sunnyvale, CA, 13 January 1968.
- 2.Spacelab - Life Sciences Mission, Life Sciences Space Laboratory Teleoperator Orbiter Bay Experiment, Deploy Sexsat Satellite, Mission 12. Summary, Rept. SE012-012-2H, Science & Engineering Directorate, NASA/MSFC, July, 1975.

E.I.103 HOLDING UNIT, SMALL VERTEBRATES  
(E.U. 40 Small Vertebrate Holding Unit.)

Purpose

The equipment item provides housing and support to small vertebrates.

Requirements

This holding unit is similar to the common holding unit, E.I. 99. However, the integral temperature control equipment will generally not be needed since the ventilating air flowing into the small vertebrate holding unit will determine the internal temperature. The small vertebrate holding unit will determine the internal temperature. The small vertebrate holding unit will also differ slightly from the common holding unit in its internal structural design peculiar to the support of the small vertebrate cages (EI 30A, EU 40).

Hardware Status

Rating: SRT

This holding unit is currently the subject of two parallel contracts, each entitled Conceptual Design for a Biological Holding Facility, which are being funded by NASA/MSFC. These contracts were awarded in May 1975 and will result in preliminary designs of the holding units. One prototype for ground based operation has been built by General Dynamics Convair Aerospace and has been used as a basis for the estimated properties given below.

Technical Description

Estimated properties of the small vertebrate holding unit were based on the use of the common holding unit (EI 99), less the thermal control equipment.

Weight	13.6 kg (30 lb) (common holding unit, EI 99 minus internal thermal control equipment)
Size	66 cm wide x 51 cm high x 56 cm deep (26 x 20 x 22 inches)
Volume	188 dm <sup>3</sup> (6.6 ft <sup>3</sup> )
Power	0

These values do not include the small vertebrate cages EI 30A which, although removable, will generally be contained within the small vertebrate holding unit. If eight small vertebrate cages (EI 30A) are added to the small vertebrate holding unit, the total weight is 32 kg (70.8 lb) and the total power is 72 watts. However, the cages are carried as separate items in the life sciences equipment inventory.

Development Time: 36 months

## E.I. 103B INCUBATOR

(E.U. 4 Preparation and Preservation Unit)

### Purpose

Growth of bacterial cultures in mini-labs for inflight analysis and preservation with subsequent return to ground.

### Requirements

Temperature	310°K (37°C, 99°F)
	(Approximate tolerance = $\pm 0.5^\circ\text{K}$ )
Internal Volume	3 dm <sup>3</sup> (0.1 ft <sup>3</sup> )

### Hardware Status

Rating: Redesign

Many commercially available incubators are available, but are generally larger than that required for the mini-labs. Thus, a custom designed unit will probably be needed. Existing space qualified components can probably be used in the design and fabrication of the incubator.

### Technical Description

The incubator is essentially an insulated cabinet with an access door and several shelves. It may be desirable to ventilate the cabinet at a low flow rate and pass the outflow through a contaminant filtering device. This has been assumed to be the case in estimating the following properties.

Weight	5 kg (11 lb)
Volume	8 dm <sup>3</sup> (0.28 ft <sup>3</sup> )
Power	5 watts

Development Time: 9 months

E.I. 105 KIT, CHEMICAL  
(E.U. 4 Preparation and Preservation Unit)

Purpose

To provide the equipment for transferring, measuring, and managing chemicals during various experiment procedures.

Requirements

This kit will be used for transferring gaseous liquid and solid samples to and from experiment equipment. Chemicals may have to be injected into various equipment components and specimens may have to be extracted and transferred to the refrigerator for storage and later ground analysis. Gas samples may require manual transfer from the experiment equipment to the gas analyzers.

In general, such procedures are expected to involve quantities on the order of 1 to 100 cc. Syringes will probably be used for most gas and liquid transfers.

Hardware Status

Rating: Repackage

Commercially available equipment will probably be usable with minor modifications and repackaging.

Technical Description

This kit is estimated to weigh 4.5 kg (10 lb) and occupy  $14.2 \text{ dm}^3$  ( $.5 \text{ ft}^3$ ) for a 30-day mission. For seven days, the weight was estimated at 1.5 kg (3.3 lb) and the volume at  $5 \text{ dm}^3$  ( $0.18 \text{ ft}^3$ ). The kit will contain such items as syringes, vials, bottles, test tubes, chemicals, leak detector fluid, stoppers, sponges, forceps, scissors, plastic bags, etc.

Development Time: 6 months

E.I. 106 KIT, HEMATOLOGY AND UROLOGY  
(E.U. 4 Preparation and Preservation Unit)

Purpose

To provide for collecting, transferring, processing, and analyzing of blood and urine.

Requirements

The requirements of the equipment within this kit will vary depending upon the specific experiments. They will also vary somewhat, depending upon the organism from which urine and blood are being collected. For purposes of conceptual design, equipment used for human collection were used as a basis for estimating the contents of this kit.

Hardware Status

Rating: Repackage

Commercial equipment should be usable. Liquids will require special containers and handling equipment. Some equipment designed for space and used on Skylab may also be applicable, such as the special 0-g blood collection and processing syringes.

Technical Description

The following is a representative list of items along with approximate weight, power, and volume for a 7-day mission.

Item	Quantity	grams	watts	cc
Alcohol, Ethanol	2	200	0	200
Alcohol Swabs	50	25	0	500
Band-Aids	25	25	0	50
Counter, Differential	1	1200	0	1000
Counter, Tally	1	50	0	50
Cover Slip (Counting Cmbr)		negl.	0	negl.
Critoseal, Clay Sealant	1	50	0	10
Gauze (2x2) & Sponges	100	50	0	300
Hemacytometer	1	100	0	300
Hemoglobinometer, Manual	1	400	0	1500
Labstix (Glu, Alb, Bld, pH, Ket, etc.)	100	25	0	100
Lancets	20	10	0	25
Luer Adapters, Vacutainer	30	50	0	10
Needles, Vacutainer (21 ga., 26 ga.)	40	10	0	10
Pipettes, Blood Diluting	30	50	0	50
Pipettes, Disposable, #10 Lambda	30	10	0	25
Pipettes, Oxford Sampler (with 100 tips)	2	50	0	100
Refractometer (AOTS meter)	1	300	0	500
Slides, Microscope (pre-stained)	50	250	0	200
Syringes, Special 0-g, Blood	10	400	0	400

E. I. 106 KIT, HEMATOLOGY AND UROLOGY (Continued)

Item	Quantity	grams	watts	cc
Syringes, Vacutainer	40	400	0	400
Tourniquet	1	50	0	50
Tubes, Microhet, Heparinixed	30	20	0	50
Tubes, Microhet, Plain	30	20	0	50
Tubes, Vacutainer, Assorted	20	20	0	50
Totals		3765	0	5930

The total weight and volume of this kit for conceptual design analysis was assumed to be:

7-Day Mission

Weight	5 kg (11.0 lb)
Volume (packaged)	9 dm <sup>3</sup> (0.32 ft <sup>3</sup> )
Power	0

Development Time: 6 months

2-3  
E.I. 106A KIT, CLEAN UP

(E.U. 6 Maintenance, Repair and Fabrication Unit.)

Purpose

To facilitate manual clean up procedures around the laboratory.

Requirements

The kit should provide the general equipment and materials to clean up both liquid and solid debris. These kits may be used during the experiments as well as at their termination.

Hardware Status

Rating: Repackage

Commercially available materials should be usable.

Technical Description

This kit may include sponges, dry wipes, chemically pre-moistened wipes, towels, swabs, disinfectant, plastic bags, plastic liners, etc. The weight and volume were estimated as follows for conceptual design purposes:

	Dedicated Laboratories	
	7-Day Mission	30-Day Mission
Weight	1.5 kg (3.3 lb)	3 kg (6.6 lb)
Volume	4 dm <sup>3</sup> (0.18 ft <sup>3</sup> )	8 dm <sup>3</sup> (0.35 ft <sup>3</sup> )
Power	0	0

Development Time: 6 months

E.I. 108 KIT, HISTOLOGY  
(E.U. 4 Preparation and Preservation Unit.)

Purpose

To provide small equipment and reagents necessary for the preparation and preservation of small tissue samples (plant and animal).

Requirements

To be determined.

Hardware Status

Rating: Repackage

The use of liquids (stains, fixatives, etc.) may require special procedures and packaging for use in null gravity.

Technical Description

The following are estimates of the weight and volume of exemplary items which would be included in the histology kit for a 7-day dedicated mission.

Item	Quantity	grams	watts	cc
Fixative, Ethanol	1	100	0	100
Fixative, Formalin	1	100	0	100
Fixative, Zenkers Soln.	1	100	0	100
Forceps, Tissue (Rattooth), Michel	2	25	0	25
Pipettes, Oxford Sampler	2	50	0	100
Stains, Assorted	4	200	0	200
Totals		575		625

The total weight and volume of the histology kit, for conceptual design purposes, was assumed to be:

	<u>7-Day Mission</u>	<u>30-Day Mission</u>
Weight	1.9 kg (2.2 lb)	3 kg (6.6 lb)
Volume	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )	3 dm <sup>3</sup> (0.11 ft <sup>3</sup> )

Development Time: 6 months

E. I. 109 KIT, LINEAR MEASUREMENT  
(E. U. 6 Maintenance, Repair and Fabrication Unit.)

Purpose

To determine size, amplitude, distance, circumference, etc.

Requirements

TRD

Hardware Status

Rating: Re-package

Commercial items adaptable

Technical Description

Contents may include:

rulers,  
tape,  
grids,  
Calipers (inside and outside),  
vernier calipers,  
micrometers (inside and outside) (as needed).

Estimated kit properties are:

Weight:	1 kg (2.2 lb)
Volume:	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )

Development Time: 4 months

E.I. 110 KIT, MICROBIOLOGY  
(Routine Biosampling and Contaminant Monitoring)  
(E.U. 4 Preparation and Preservation Unit)

Purpose

To provide tools to facilitate growing and analyzing microbial organisms.

Requirements

To be determined.

Hardware Status

Rating: Repackage

Most ground-based commercial equipment should be usable in space.

Technical Description

The following is a representative list of items needed in a microbiology kit for a 7-day dedicated laboratory.

Item	Quantity	grams	watts	cc
Alcohol, Ethanol	1	50	0	50
Counter, Tally	1	50	0	50
Loop, Inoculating	2	10	0	20
Media, Blood Agar, Plated	7	100	0	200
Media, Emb Agar, Plated	7	100	0	200
Media, Phenylethyl Alcohol	7	100	0	200
Media, Stuart Transport	7	100	0	200
Media, TSA Agar, Plated	7	100	0	200
Needles, Inoculating	2	10	0	10
Pipettes, Oxford Sampler	2	50	0	100
Slides, Microscope	50	200	0	200
Swabs, Cotton	50	25	0	500
Syringe, 5 ml, sterile	1	10	0	10
Thioglycollate, tubed	7	50	0	50
TSA Slants	7	50	0	50
Tubes, 15 x 75 mm, sterile	10	50	0	150
Zephiran, Tincture, 1:500	1	50	0	50
Totals		1105	0	2240

The total weight, power, and volume values assumed for conceptual design purposes were:

	<u>7-Day Mission</u>	<u>30-Day Mission</u>
Weight	2 kg (4.4 lb)	6 kg (13.2 lb)
Power	0	0
Volume	3 dm <sup>3</sup> (0.11 ft <sup>3</sup> )	8 dm <sup>3</sup> (0.28 ft <sup>3</sup> )

Development Time: 6 months.

E.I. 110C KIT, HUMAN PHYSIOLOGY  
(E. U. 31 Biomedical Research Support Unit.)

Purpose

To provide necessary small equipment items for physiological measurements.

Requirements

Specific requirements have yet to be determined. This kit will be used to support both biomedical and MSI experiments.

Hardware Status

Rating: Re package

Most of this equipment can be of the commercial type used on the ground.

Technical Description

Representative equipment items and preliminary estimates of weight, power, and volume are listed below for a 7-day dedicated laboratory

Item	Quantity	grams	watts	cc
Counter, Tally	1	50	0	50
Cuff, Blood Pressure	1	1000	0	300
Electrodes, ECG, VCG, etc., Disposable	20	10	0	50
Flowmeter, Doppler, Blood	1	450	1	250
Harness, Electrophysiology	1	450	0	3000
Labstix (Glu, Alb, Blood, pH, Ketone)	100	50	0	100
Oto-Opthalmoscope (Battery)	1	150	0	350
Respirometer, Strain Gage	2	50	0	500
Sphygmomanometer	1	300	0	500
Spirometer Mouthpieces	3	50	0	500
Stethoscope	1	100	0	600
Thermistor, Deep Body Temp.	2	50	0	50
Thermometer, Oral	4	50	0	25
Tuning Fork	1	100	0	200
Totals		2860	1	6475

For conceptual design definition purposes, the total weight, power, and volume of the human physiology kit was estimated at:

Weight	3 kg (6.6 lb)
Power	negl.
Volume	8 dm <sup>3</sup> (0.28 ft <sup>3</sup> )

Development Time: 6 months.

E.I. C111 KIT, PLANT MANAGEMENT  
(E. U. 51 Plant Research Support Unit.)

Purpose

This kit provides tools and components for various plant research procedures.

Requirements

To be determined.

Hardware Status

Rating: Re-package

Commercially available ground-based equipment should be applicable with slight modifications.

Technical Description

Representative components of this kit for a 7-day dedicated mission are listed below:

Item	Quantity	grams	watts	cc
Applicator	10	20	0	20
Blades, Surgical	25	25	0	10
Forceps, Gilbert	2	20	0	20
Forceps, Splinter	2	20	0	20
Knife, Holder, Bard Parker	2	50	0	10
Needles, Syringe	20	10	0	10
Photocells	4	100	Negl	50
Plastic Bags (small)	10	100	0	50
Scissors, Mayo-Nobel Dissection	2	20	0	10
Scalers	3	5	0	10
Spatulas	10	20	0	20
Splints	8	20	0	20
Squib Firing Mechanism	1	50	0	25
Squibs (Plant Growth Arresters)	10	50	0	25
String	1	30	0	30
Syringes	10	50	0	50
Tape	1	50	0	50
Totals (Exemplary Equipment)		640	0	430

The total weight, power and volume for this kit were assumed to be:

	<u>7-Day Mission</u>	<u>30-Day Mission</u>
Weight	1 kg (2.2 lb)	2 kg (4.4 lb)
Power	0	0
Volume	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )	2 dm <sup>3</sup> (0.07 ft <sup>3</sup> )

Development Time: 6 months

E.I. 113A KIT, INVERTEBRATE MANAGEMENT  
(E.U. 70 - Invertebrate Holding Unit)

Purpose

To provide tools and materials for working with invertebrate organisms.

Requirements : TBD.

Hardware Status

Rating: Repackage.

Most of the items used in ground applications should be suitable for use in space. Minor modifications will be required as well as special packaging and restraints.

Technical Description

Typical contents of this kit include tongs, tweezers, forceps, syringes, scissors, plastic bags, vials, slides, tubes, alcohol, etc.

The estimated weight and volume of this kit for a 7-day dedication laboratory are:

Weight:	1 kg (2.2 lb)
Volume:	2 dm <sup>3</sup> (0.071 ft <sup>3</sup> )
Power:	0
Location:	Preferred stowage location would be near the Holding Unit, Invertebrates (E.I. 98C, E.U. 70).
Interfaces:	None

Development Time: 6 months

E.I. 114A KIT, DISSECTION  
(E. U. 4 Preparation and Preservation Unit.)

Purpose

This kit provides small equipment for surgical procedures organisms.

Requirements

Procedures to be performed may include surgery on vertebrates for purposes of collecting tissue samples and other specimens, or implanting sensors. Specimen collection from plants, invertebrates, and amphibians may be required. Other specific requirements have yet to be determined.

Hardware Status

Rating: Re package

Commercially available - minor modifications may be required.

Technical Description

Representative components along with their estimated weight and volume are listed below:

Item	Quantity	grams	watts	cc
Blades, Surgical	25	25	0	10
Chloral Hydrate	1	25	0	25
Forceps, Gilbert	2	20	0	20
Forceps, Needle, Metzenbaum	2	20	0	20
Knife Holder, Bard Parker	2	50	0	10
Microsurgery Set	1	450	0	1000
Needles, Assorted	15	25	0	25
Needles, Suture, Assorted	15	25	0	25
Nembutal	1	25	0	25
Retractor, Weitlaner	20	10	0	10
Scissors, Mayo-Nobel, Dissecting	2	50	0	25
Scissors, Operating	2	50	0	25
Suture Material, Monofilament	1	5	0	10
Totals (Exemplary Equipment)		780	0	1230

The following total weight and volume were assumed for conceptual design purposes for both 7- and 30-day missions:

Weight	1 kg (2.2 lb)
Volume	2.0 dm <sup>3</sup> (0.07 ft <sup>3</sup> )
Power	0

Development time: 6 months

E.I. 114B KIT, VERTEBRATE MANAGEMENT  
(E. U. 42 Vertebrate Research Support Unit.)

Purpose

To provide tools and devices used in the handling of vertebrates.

Requirements

The contents of this kit will depend upon the experiments being conducted and the specific organisms being used.

Hardware Status

Rating: Re package

Ground-based equipment with minor modifications is generally applicable.

Technical Description

This kit was assumed to include 20 plastic bags, 10 towels, an organism transfer/restraint capsule, 12 animal tags, 4 organism harness-type restraints, 4 photocells and a universal animal dissection board. Estimated weight and volume for this kit for both 7- and 30-day missions are approximately:

Weight:	3 kg (6.6 lb)
Volume:	6 dm <sup>3</sup> (0.21 ft <sup>3</sup> )

Development Time: 6 months

E.I. 114C KIT, VERTEBRATE PHYSIOLOGY  
(E.U. 42 - Vertebrate Research Support Unit)

Purpose

To provide equipment and materials for setting up and conducting physiological measurements on vertebrates.

Requirements

Specific requirements have yet to be determined and will be somewhat experiment specific. Also, for the short duration missions, much of the preparation for physiological measurements will be performed prior to flight. Organisms to be considered include small vertebrates such as rats, and primates such as macaque monkeys.

Hardware Status

Rating: 1epackage.

Most of the items used in ground applications should be suitable for use in space. Some modifications will be required as well as special packaging and restraints.

Technical Description

Some typical items in this kit are listed below along with preliminary estimates of weight, power, and volume.

Item	Quantity	grams	watts	cc
Alcohol	2	200	0	200
Biobackpack, micro	2	25	0	25
Chloral Hydrate	1	25	0	25
Cuff, Blood Pressure & Pump	1	300	0	100
Drugs, Miscellaneous*	1	200	0	200
Electrodes, ECG, EEG, etc.	20	10	0	50
Flowmeter, Doppler, Blood	1	450	1	250
Harness, Electrophysiology, Small	2	25	0	25
Labstix	100	50	0	100
Nembutal	1	25	0	25
Razor	1	30	0	75
Respirometer, Strain Gage	2	50	negl.	500
Scissors	2	100	0	200

\*Drugs may include any of the following as needed: Adrenalin, Coramine, Penicillin, Streptomycin, Chlorpromazine, Pentothal, Nembutal, Atropine, Scopolomine, Phenobarital, Morphine, Sulfadiazine, Demerol, Paregoric, Diphenhydramine Hydrochloride.

## E. I. 114C (Cont'd)

Item	Quantity	grams	watts	cc
Sensors, Implantable	4	40	negl	10
Sphygmomanometer (mechanical)	1	800	0	1600
Stethoscope	1	100	0	600
Swabs	50	25	0	500
Syringes	4	20	0	50
Tape Measure	1	20	0	25
Thermistor, Deep Body Temp.	2	25	negl.	25
Thermometers	2	80	0	100
Transducer, Venous Press, Implantable	1	5	negl.	5
Totals		2605	1	4690

Preliminary estimates for the packaged weight, power, and volume of the animal physiology kit for the dedicated laboratories are shown below. These values would be applicable for both 7 and 30 day missions since the change in consumables is negligible.

Weight	3.0 kg (6.6 lb)
Power	Negligible
Volume	6 dm <sup>3</sup> (0.21 ft <sup>3</sup> )

Development Time: 6 months

E.I. 114E LAMP, PORTABLE HIGH INTENSITY PHOTO  
(E. U. 1 Visual Records and Microscopy.)

Purpose

Illumination of subjects during photographic or still documentation

Requirements

To be determined.

Hardware Status

Rating: Modification

A photographic lamp is currently being built for Shuttle by Sylvania. It was assumed herein that the Shuttle lamp would be usable in the laboratories with minor modifications.

Technical Description

The weight and power of this lamp was estimated based on a previous lamp used on Skylab which weighed 6.26 kg (13.8 lb) and used 150 watts. The volume was estimated at 6 dm<sup>3</sup> (0.21 ft<sup>3</sup>), stowed.

Development Time: 6 months

E.I. 114G LIQUID STORAGE & DISPENSING SYSTEM  
(E. U. 3 - Life Sciences Experiment Support Unit)

Purpose

This system will provide for general purpose liquid storage and dispensing, generally to be used for water.

Requirements

A liquid capacity of 12 dm<sup>3</sup> (3.2 gallons) was assumed for preliminary design purposes.

Hardware Status

Rating: Modification.

Previous spaceflights like Skylab have included water storage and dispensing systems. These designs should be adaptable to the life sciences laboratory requirements with minor modifications.

Technical Description

The system was assumed to utilize gaseous carbon dioxide from a self-contained storage system for pressurization of a positive expulsion (bladder type) water tank. Water would be dispensed through a valve-nozzle device. Estimated properties for both 7- and 30-day dedicated missions are presented below.

	Weight kg	Envelope Volume dm <sup>3</sup>
<u>For 7 Days</u>		
Fixed hardware (one tank + plumbing)	3	18
Water	<u>10</u>	<u>in tank</u>
Totals	13	18
<u>For 30 Days</u>		
Fixed hardware (3 tanks + plumbing)	8	52
Water	<u>36</u>	<u>in tank</u>
Totals	44	52

Power: 0  
Heat Rejection: 0

E.I. 114G (Cont'd)

Data Management:	Monitor water flow during water withdrawal.
Location:	TBD
Interfaces:	CDMS

Development Time: 12 months

E.I. 115F LIFE SUPPORT SYSTEM (LSS) TEST CONSOLE  
(E.U. 80 - LSS Test Unit)

Purpose

To provide mounting space and interface equipment for Life Support & Protective Systems (LSPS) test apparatus.

Requirements

The space allowed was 96.5 cm W  $\times$  76.2 cm H  $\times$  76.2 cm D, which can be accommodated within a double Spacelab rack. The test console should provide connections for various utilities to support LSPS testing. These should include water, vacuum, electrical power, liquid coolant, gases and instrumentation interconnects. The test volume should be capable of being encapsulated with a gas-tight shroud for safety purposes when testing equipment containing flammable or toxic gases.

Hardware Status

Rating: New Development

This console will have to be designed and built. No intractable design problems have been identified.

Technical Description

This equipment item is essentially the structural and interconnect hardware needed to support various LSPS test apparatus. It will be inserted into the Spacelab racks. It will contain attachments for the installation of flexible, transparent shroud. This shroud will be used as needed to isolate the test equipment from the cabin atmosphere. The estimated properties of the LSPS test console are:

Weight:	15 kg (33 lb)
Envelope Dimensions:	96.5 cm W $\times$ 76.2 cm H $\times$ 76.2 cm D (38" W $\times$ 30" H $\times$ 30" D)
Envelope Volume:	560 dm <sup>3</sup> (19.8 ft <sup>3</sup> )
Power & Heat Rejection:	0
Location:	Place in Spacelab double rack. This equipment must be placed so that it is conveniently accessible by the crew. Access to the front of this space is necessary and access to one side would be desirable but not mandatory.

## E.I. 115F (Cont'd)

### Interfaces:

LSPS test hardware will be supported by various equipment items in the inventory. Thus, the LSPS Test Console must provide compatible interfaces between these E.I.s and the LSPS test hardware. Some of these E.I.s are listed below.

1. The camera equipment (E.U. 1).
2. Various data management E.I.s such as couplers, oscilloscope, numeric read-out, etc. (E.U. 2).
3. Coolant loop liquid (E.I. 51F, E.U. 3).
4. Equipment restraint device (E.I. 70C, E.U. 3).
5. Gas Analyzer, Infrared (E.I. 87, E.U. 5).
6. Gas Analyzer, Mass Spec. (E.I. 91, E.U. 5).
7. Gas supplies (E.I. 93A, E.U. 3).
8. Liquid storage & dispensing system (E.I. 114G, E.U. 3).
9. Manifold, vacuum (E.I. 118I, E.U. 3).
10. Plumbing (E.I. 141A, E.U. 3).
11. Recorder, Strip Chart (E.I. 150A, E.U. 1).
12. Multimeter (E.I. 185, E.U. 6).

### Operations:

TBD.

Development Time: 24 months

E.I. 116 LOG BOOKS  
(E.U. 1 - Visual Records and Microscopy Unit)

Purpose

To write down experiment notes, results, procedures and comments.

Requirements

A standard type notebook with a 0-g hold-down device should be acceptable.

Hardware Status

Rating: Space Qualified.

Log books of the type used in previous space flights should be available.

Technical Description

Estimated weight and volume requirements for 7 days are:

Weight:	0.5 kg (1.1 lb)
Volume:	0.4 dm <sup>3</sup> (0.014 ft <sup>3</sup> )

Development Time: Negl.

E.I. 117 LOWER BODY NEGATIVE PRESSURE DEVICE (LBNPD)  
(E.U. 31 - Biomedical Research Support Unit)

Purpose

The LBNP Device is used to apply a negative pressure to the lower abdomen and legs of the crewmen.

Requirements

Requirements for the LBNP Device were based upon the existing design used in Skylab. Skylab provided equipment to measure leg volume, blood pressure, body temperature, and a vectorcardiogram as a part of the In-Flight Lower Body Negative Pressure Experiment (No. M092), Ref. cited below. Operational data for the LBNPD taken from the reference is given below.

M092 LBNPD Operational Data		
<u>Parameter</u>	<u>Value</u>	<u>Unit</u>
Volume (Internal)	10.0	ft <sup>3</sup>
Operating Temperature Range*	67 to 78	°F
Nominal Operation Range Below Cabin Atmosphere	0 to 50	mm Hg
Maximum Negative Operating Pressure Below OWS Ambient of 3.7 to 15.5 psia	50	mm Hg
Leakage	2.5	ft <sup>3</sup> /min (max.) @ 50 mm Hg $\Delta P$ and 5 psia

\*Desired ambient range to provide subject comfort.

Hardware Status

Rating: Space Qualified

The Skylab design should be applicable with minor modifications.

Technical Description

The LBNPD is an anodized aluminum cylindrical chamber fitted with a waist seal to allow the crewman to insert his legs and lower abdomen into the chamber and seal the chamber for depressurization.

E.I. 117 (Cont'd)

The LBNPD is shown in the attached pictures. The properties of the LBNPD are listed below:

**Weight:**

LBNPD	62.1 kg (137 lb)
Ancillary Equipment	16.6 kg (36.6 lb)
Total	78.7 kg (173.5 lb)

**Dimensions:**

LBNPD Envelope 267 × 114 × 76 cm (105 × 45 × 30 inches)

**Envelope Volume:**

LBNPD	2,313 dm <sup>3</sup> (81.7 ft <sup>3</sup> )
Ancillary Equipment	60 dm <sup>3</sup> (2.12 ft <sup>3</sup> )
Total	2,373 dm <sup>3</sup> (83.8 ft <sup>3</sup> )

**Power:**

26 watts, 28 volt, d.c. (when on - about 25 minutes per use) (voltage range limits are 22 to 30 v. d.c.)

**Heat Rejection:**

26 watts to air (when on)

**Data Management:**

Analog data to be transferred to the CDMS includes the following (obtained from the Reference):

**M092 Analog Measurements**

Parameter/Measurement Number	Quantity	Measurement Range	Resolution (± F.S.)	Accuracy
LBNP Pressure Differential/ D7130M092	1	0 to 50 mm Hg	1.6	±1.0 mm Hg
Plethysmograph Leg Volume/ P7004M092 (Left) and P7016M092 (Right)	2	-1 to 5%	2.0	±20%
BPMs Systolic Blood Pressure/ P7011M092	1	50 to 250 mm Hg	0.4	±10 mm Hg
BPMs Diastolic Blood Pressure/ P7030M092	1	40 to 140 mm Hg	0.4	±10 mm Hg
LBNPD Internal Chamber Temperature/ C7030M092	1	65° to 100°F	0.5	±0.25°F
Ambient Temperature	1	60 to 95°F	1.0	±0.5°F

**Location:**

No constraints other than convenient placement and interconnections during use.

**Interfaces:**

EPS-CDMS-Vacuum Manifold (E.I. 118I, E.U. 3)-Coupler, Vectorcardiogram (E.I. 182J, E.U. 31)-Signal Conditioners (E.I. 156, E.U. 2).

**Operations:**

Limitations and constraints include:

1. LBNPD maximum negative pressure, 50 mm Hg.
2. Crewmen must not be subjected to acceleration greater than  $10^{-4}$  g during conduct of the experiment.

E.I. 117 (Cont'd)

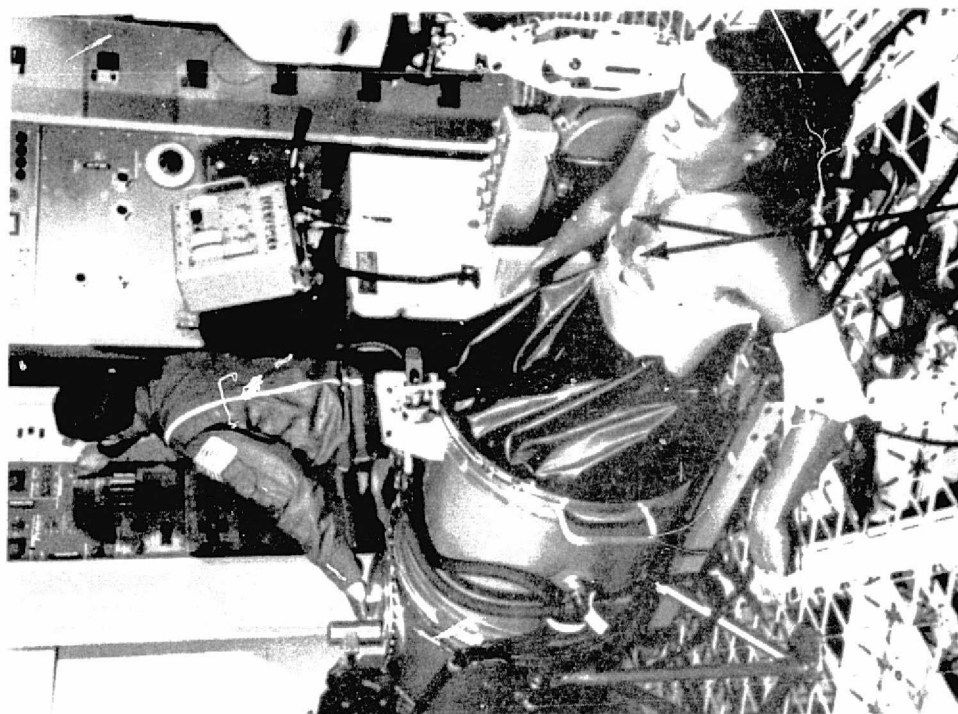
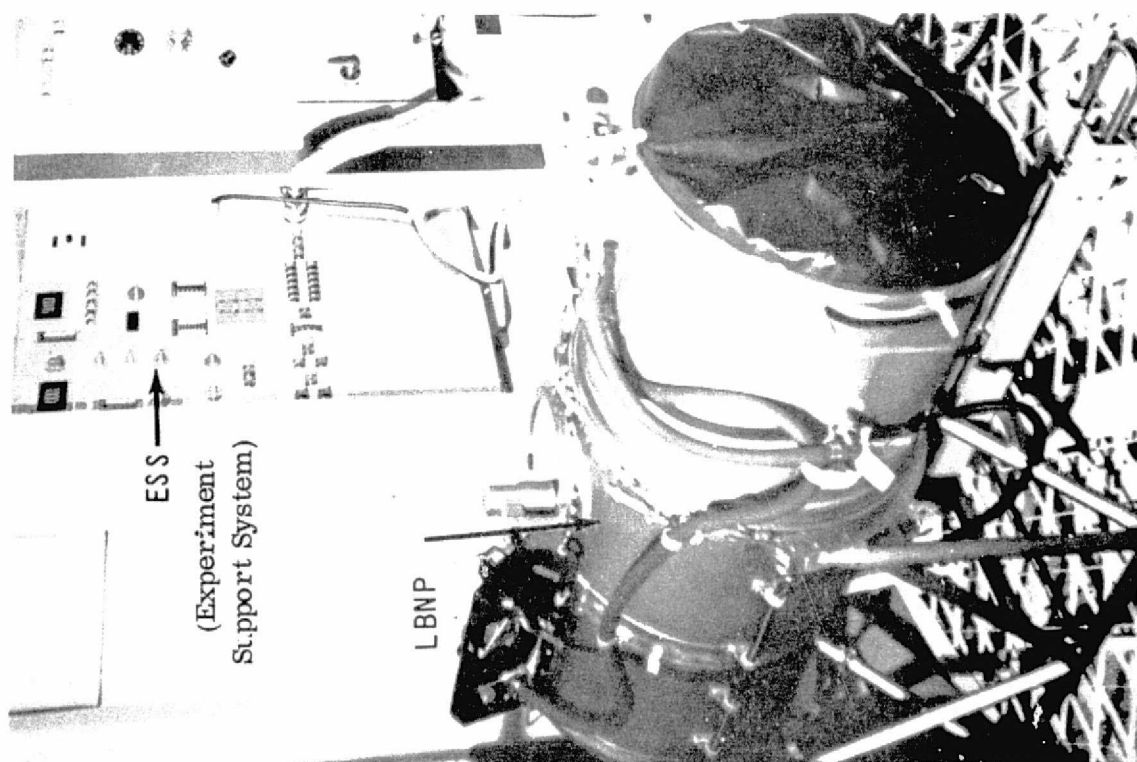
3. The ambient temperature must be 292 to 299°K (67 to 78°F).
4. LBNPD internal temperature must not exceed 300°K (80°F).

Development Time: 12 months

Reference

Skylab Program OPERATIONAL DATA BOOK, VOL. I, Part One, Revision A, Report No. MSC-01549 (Vol. I) Rev. A, NASA, Manned Spacecraft Center, Houston, Tex., October 1972.

# IN-FLIGHT LOWER BODY NEGATIVE PRESSURE SKYLAB EXPERIMENT M092



BPMS  
(Blood Pressure  
Measurement System)  
VCG

E.I. 118I MANIFOLD, VACUUM  
(E. U. 3 Life Sciences Experiment Support Unit.)

Purpose

To provide a source of vacuum for experiment equipment, such as the LBNP.

Requirements

The item is intended to include all equipment necessary to interface with the Space-lab in order to provide a vacuum supply to the life sciences laboratory equipment. This may include valves, gages, connectors, and fittings as well as the manifold tubing. The vacuum manifold is needed for LSPS experiment purposes such as pumping CO<sub>2</sub> out of zeolite beds (molecular sieves), vacuum purging toxic or explosive gases from test units, providing vacuum for thermal insulation, and vacuum drying waste matter. The pumping rates required are not known. However, a manifold with a diameter of 2.54 cm (1 inch) was assumed for purposes of conceptual design definition.

Hardware Status

Rating: Re-design

Hardware suitable for this vacuum manifold system should be available.

Technical Description

The weight volume of this system will be dependent upon the Spacelab configuration and placement of the equipment within the Spacelab. Preliminary estimates are:

Weight	9.1 kg (20 lb)
Power	0
Volume	28.3 dm <sup>3</sup> (1 ft <sup>3</sup> )

Development Time: 12 months.

E.I. 121 MASS MEASUREMENT DEVICE, MACRO  
(E.U. 4 - Preparation & Preservation Unit)

Purpose

To measure the mass of items such as food, liquids, urine, feces, specimens, organisms, etc.

Requirements

The mass measurement range of this device will have to be determined through future studies of the several mass measurement devices intended for use in the life sciences laboratories. These include the Body Mass Measurement Device (E.I. 19D, E.U. 31) and the Mass Measurement Device, Micro (E.I. 122, E.U. 4). A range of approximately 5 g to 2 kg was chosen for use at this time. This corresponds closely to the Specimen Mass Measurement Device (SMMD) used on Skylab. Larger masses can be measured on the Body Mass Measurement Device, and smaller masses on the Mass Measurement Device, Micro.

Hardware Status

Rating: Redesign

A specimen mass measurement device (SMMD) was used aboard Skylab (Experiment M074). It had a specified measurement range of 50 g to 1 kg, with an accuracy of  $\pm 0.1\%$  for rigid masses. However, its range was much larger if slightly reduced accuracy was acceptable. It could probably be easily extended to 5 g to 2 kg (Ref. Ray McKemey, NASA/MSC). Thus, the Skylab SMMD would probably be acceptable for use in the Life Sciences Laboratory. However, the weighing platform should probably be modified to accept larger items than were acceptable with the SMMD. The SMMD was manufactured by Southwest Research Institute, San Antonio, Texas.

Technical Description

This description is based upon the Skylab SMMD as it is presented in the reference cited at the end of this writeup. Mass determinations are achieved by using a linear spring/mass pendulum platform. The mass of the object being measured is determined by the period of the pendulum. The period is electronically timed and is converted graphically to direct mass readings. The SMMD unit is calibrated on the ground using the calibration masses and rechecked in orbit under weightless conditions, with the same masses.

## E.I. 121 (Cont'd)

The SMMD consists of a specimen tray supported on plate-fulcrum springs and a period/temperature measuring electronic subsystem with a digital display. The tray is locked in a fixed position except during operation so that there are no parts to vibrate or become displaced. For operation, the specimen tray is unlocked and then released with a single movement of the control lever, allowing the free oscillation of the mass in response to the thrust provided by the plate-fulcrum springs which are initially locked in a displaced position. The SMMD electro-optical system counts and displays the time period for three oscillations of the mass. The time period is used to compute the mass of the object on the tray. A calibration mass assembly consists of a mounting post and a set of four cylindrical masses (50, 100, 250, and 500 grams) that are used to calibrate the SMMD during preflight and in-flight operation. The electronics subsystem electronically times the pendulum and provides direct time readout which will be converted into mass measurements. The electronics subsystem module also houses a temperature sensor and the necessary electronic circuitry to measure and display the temperature of the pendulum spring in degrees Fahrenheit.

The Skylab mass measurement device has an accuracy of  $\pm 0.1$  percent for rigid masses. Samples containing liquids with a gas content of less than 5 percent by volume can be measured with an accuracy of  $\pm 2$  percent.

The properties of the Skylab SMMD are used herein as preliminary estimates for the life sciences laboratory unit. They are given below.

### Weight:

SMMD	10.7 kg (23.5 lb)
Calibration Equipment	1.13 kg (2.5 lb)
Total	11.83 kg (26 lb)

### Dimensions:

SMMD	39.6 cm W $\times$ 33 cm H (including electronics module) $\times$ 24.6 cm D (15.6" W $\times$ 13" H $\times$ 9.7" D)
Calibration Equipment	7.6 $\times$ 7.6 $\times$ 10.2 cm (3 $\times$ 3 $\times$ 4 inches)

### Envelope Volume:

SMMD	32.2 dm <sup>3</sup> (1.14 ft <sup>3</sup> )
Calibration Equipment	0.59 dm <sup>3</sup> (0.02 ft <sup>3</sup> )

Power: 15 watts, 28 v. d.c.

Heat Rejection: TBD. Depends upon usage. Air cooled.

## E.I. 121 (Cont'd)

### Data Management:

The period of oscillation and the unit temperature are read out on the electronics subsystem module. Data is voice transmitted to the ground for the computation of masses. Aboard Spacelab, the data could be transmitted to the CDMS via the data bus for subsequent analysis or transmission to the ground.

### Location:

Rack mount with the front face exposed.

### Interfaces:

EPS

### Operations:

1. Specimens to be weighed on the Skylab device had to fit within a  $20.3 \times 33.7$  cm ( $8 \times 13.25$  inch) tray and be held in place by a rubber tie-down sheet. Their height was limited to 2.54 cm (1 inch) or less.

2. The mass measurement device should be operated within 291 to 300°K (65 to 80°F) for best accuracy.

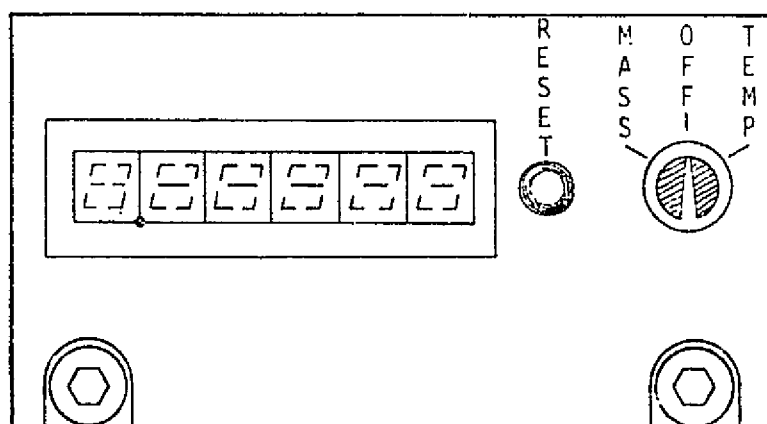
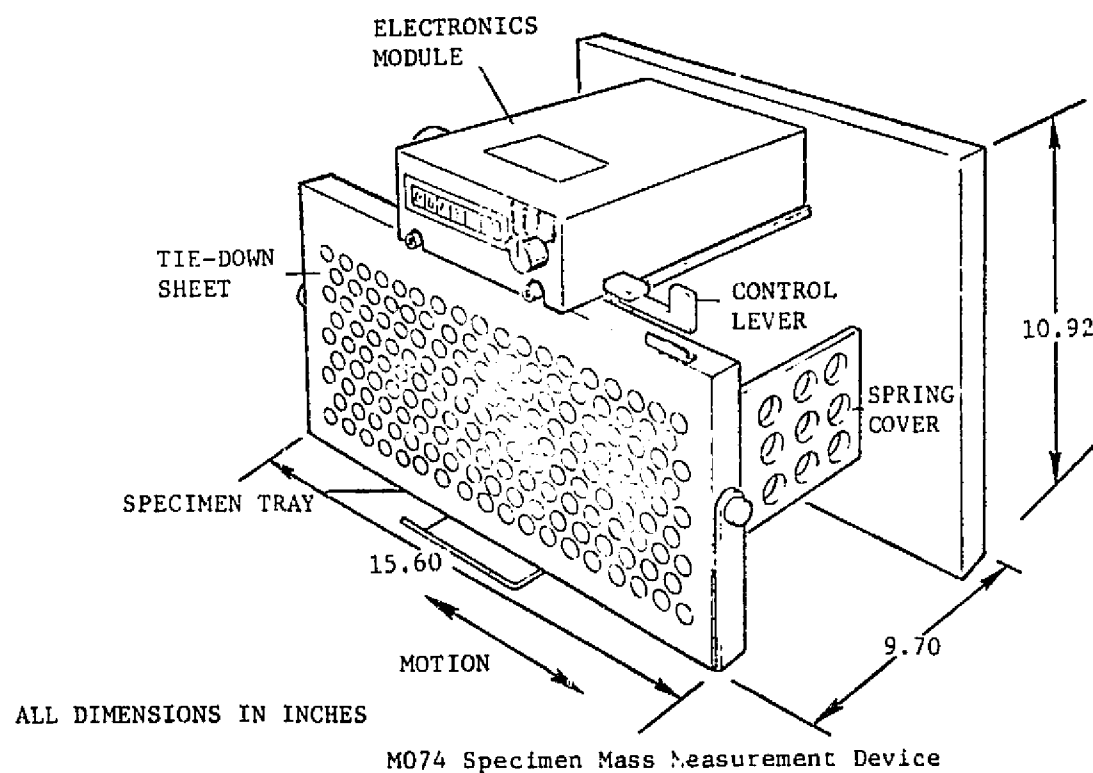
3. The spacecraft acceleration cannot exceed  $1.3 \times 10^{-4}$  g during calibration.

4. Operating voltage limits are:  
Maximum, 30 V d.c. nominal  
" , 33 V d.c. for one second  
Minimum, 24 V d.c. nominal  
" , 21 V d.c. for one second

Development Time: 12 months

### Reference

Skylab Program OPERATIONAL DATA BOOK, VOL. I, Part One, Revision A, Report No. MSC-01549 (Vol. I) Rev. A, NASA, Manned Spacecraft Center, Houston, Texas, October 1972.



Electronics Subsystem Module

E.I. 122 MASS MEASUREMENT DEVICE, MICRO  
(E.U. 4 - Preparation & Preservation Unit)

Purpose

To measure the mass of small biospecimens and other small solid and liquid items such as would be weighed on a laboratory analytical balance.

Requirements

Life scientists have stated a need to be able to weigh very light objects during various research procedures. However, many of these measurements can be obviated by the use of pre-weighing and by the use of preservation with subsequent weighing and analysis on the ground. According to Ray McKenney at NASA/JSC, the need for this mass measurement device has not been firmly established. However, it is included herein since its need is still open to question.

According to UCSD scientists, the capability to weigh items as light as 0.1 mg is preferred but 1 mg would be acceptable for most experiments. Thus, a mass range of 1 mg to 5 g would be suitable for the Mass Measurement Device, Micro. The accuracy required is yet to be determined.

Hardware Status

Rating: New Development

A device to accurately weigh very small masses in null gravity will have to be developed. If an oscillatory device of the type used in Skylab is used, it will probably require an evacuated enclosure to minimize the effects of air currents.

Technical Description

The preliminary properties which were used for conceptual design purposes are listed below.

Weight:	12 kg (26.5 lb)
Envelope Volume:	25 dm <sup>3</sup> (0.88 ft <sup>3</sup> )
Power:	15 watts, 28 volt d.c. when on
Heat Rejection:	15 watts when on. Average rate will probably be negligible.
Data Management:	TBD
Interfaces:	EPS & possibly the Vacuum Manifold (E.I. 118I, E.U. 3)

Development Time: 36 months

E.I. 124 MEDIA, PREPARED  
(E.U. 61 - Cell and Tissues Research Support Unit)

Purpose:

To support organism growth.

Requirements:

Isolation from contaminants.

Hardware Status:

Rating: Repackage.

Commercially available.

Technical Description:

Microorganism culture media can be stored in sterilized and sealed bottles, aluminum foil packets, metal containers, vials, etc.

Weight:	0.45 kg (1.0 lb)
Volume:	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )

Development Time: Negl.

E.I. 126 MICROSCOPE, COMPOUND  
(E.U. 1 VISUAL RECORDS AND MICROSCOPY)

Purpose

To provide the experimenter with a versatile binocular microscope for studies of tissues, cells, bacteria, etc., and to permit photography as well as video transmission to ground of selected images.

Requirements

The following features have been stated by cognizant life scientists as being desirable:

Binocular construction  
Photographic capability

Lighting system to include bright field, dark field, phase contrast,  
and polarizing capability  
Video camera adaption equipment available for use

These features may be subject to compromise depending upon the particular mission and experiments being conducted. In some cases, the desired capabilities impose requirements for certain accessory attachments. Thus these attachments can be deleted if the related capability is not needed for a particular mission.

In the way of general requirements of the compound microscope, (1) it should be versatile enough to provide a broad range of capability, (2) it should be high quality for good photographic reproductions and (3) it should be easily used and adapted to various requirements.

Hardware Status

Rating: Modification

A small monocular microscope and accessories were flown aboard Skylab. However, a higher quality microscope will be required for the life sciences laboratories. There are many commercially available microscopes which can probably be used in space with minor modifications. The literature on several types was briefly reviewed to determine their relative suitability for use. The four microscopes reviewed were (1) the Bausch & Lomb Balplan microscope, (2) the American Optical Series 10 and 20 Microstar microscopes, (3) the Zeiss Standard microscope, and (4) the Wild Heerbrug M12 microscope.

E.I. 126 MICROSCOPE, COMPOUND (continued)  
(E.U. 1 VISUAL RECORDS AND MICROSCOPY)

All of these microscopes are good quality, general purpose laboratory microscopes. Among these four, the Zeiss Standard microscope was selected for inclusion in the life sciences laboratories. It is constructed primarily of aluminum alloy and is reportedly lighter than some of the other microscopes. Zeiss also offers multiple accessories and a broad range of quality in its components for use with its standard microscopes. For example, the highest quality Planapochromat objectives are available at about \$1,000 each for exceptional visual and photographic resolution and flatness of field. On the other hand, standard quality achromat objectives at competitive prices are available for use. UCSD consultants recommended the use of Zeiss compound microscope equipment. They also favored future consideration of a higher quality Zeiss model such as the "Universal" microscope. Whether this more costly microscope is justifiable will depend upon definition of experiments. For preliminary purposes, the Standard 18 model was used herein.

The Zeiss Standard microscope appears to be compatible with the Spacecraft environment with minor modifications. An illumination bulb using 28 volt d.c. would be desirable along with a variable d.c. power supply for light intensity control. Zeiss representatives have stated that a d.c. powered quartz halogen lamp is available. The power supply could easily be built.

Technical Description

The Zeiss Standard 18 microscope is of modular construction. As such, it can be built up from optional components to satisfy individual requirements. The basic setup selected herein was based upon the requirements stated earlier for brightfield, darkfield, phase contrast, and polarized illumination. However, to satisfy all the requirements, some accessory equipment is necessary, and is included in the microscope accessory kit (E.I. 126J, E.U. 1). The major components of the basic microscope are listed below.

<u>Item</u>	<u>Catalog #</u>
1. Stand, Standard 18 for removable specimen holder	470918
2. Binocular photo tube with sliding prism	473026
3. Rotating and centering mechanical stage, graduated (for polarized light work)	473457
4. Quadruple nose piece with dovetail	473140

E.I. 126 MICROSCOPE, COMPOUND (continued)  
(E. U. 1 VISUAL RECORDS AND MICROSCOPY)

<u>Item</u>	<u>Catalog #</u>
5. 10 watt In-Base Halogen Illumination (for true color TV reproduction)	
a. Diaphragm insert, 6 volt 10 watt lamp socket, lamp, and auxiliary condenser lens EL POL	465144
b. DC power supply for lamp, variable voltage, 28 volt, d.c. input power	design item
6. Brightfield/phase contrast/dark condenser V. Z, N.A. 1.4	465277
7. 10X Kpl eyepieces WW-BR (2)	464042
8. Objectives	
a. Planachromat 2.5/0.08	460110
b. Planachromat 10/0.22	460410
c. Planachromat 40/0.65	460710
d. Planachromat 100/1.25 w/iris oil	461916

Totals

\*Costs were based on 1 July 1974 price list plus 10% to account for subsequent price increases.

Polarized light studies are possible with the rotating stage selected for use. However, simple polarization accessory equipment is necessary, and is included in the microscope accessory kit. The 10 watt illumination is reportedly adequate for TV microscopy with color vidicons of usual light sensitivity. Quartz halogen illumination is necessary for true color reproduction without the use of filters. If more light is needed, a 100 watt halogen illuminator is available. The planachromat objectives produce a very flat field of view, edge-to-edge, and are especially suited to bright field and photo microscopy use. Other special purpose objectives may be substituted as required.

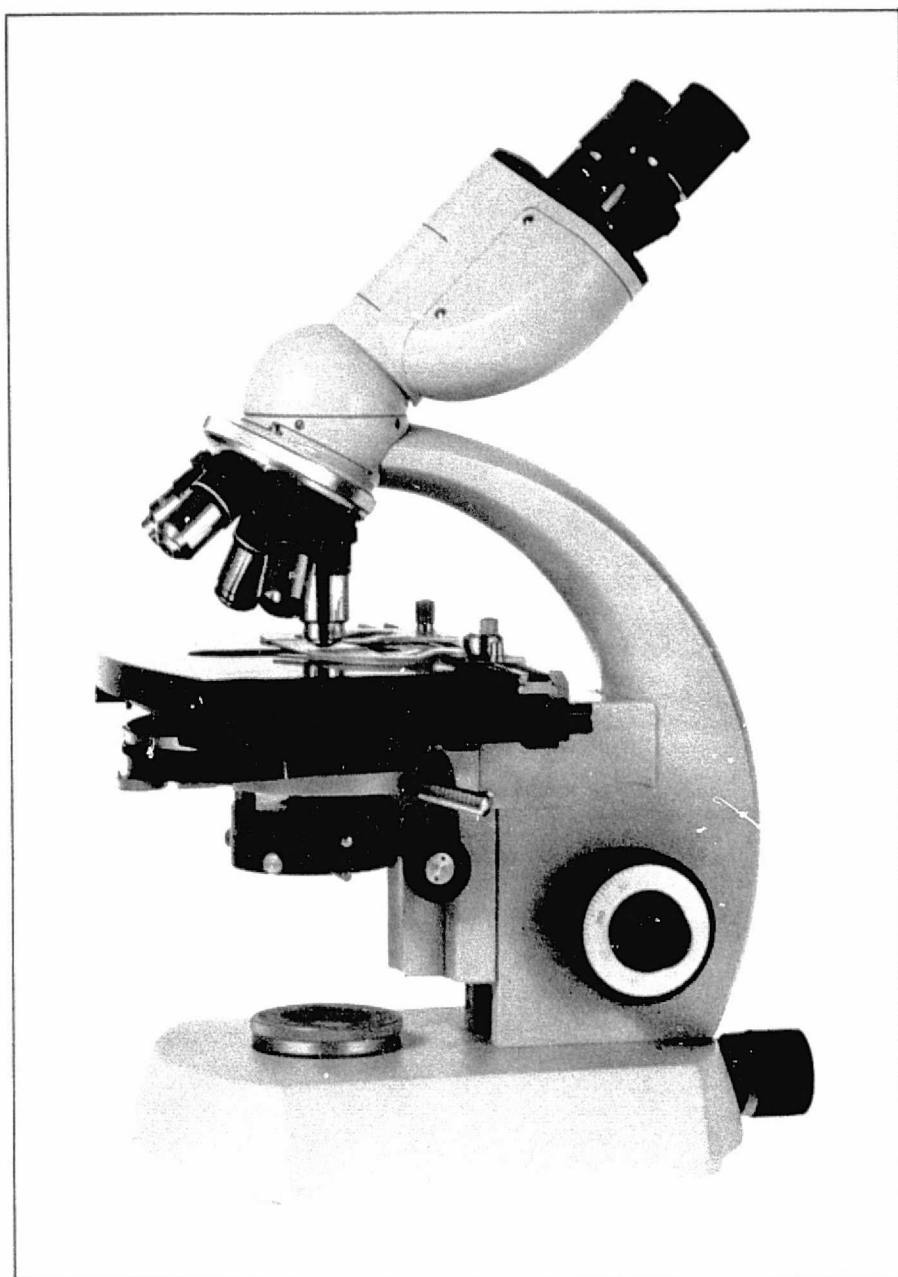
The approximate properties of the overall Zeiss Standard 18 microscope are listed below:

Weight:	11 kg (24.3 lb)
Envelope Dimensions:	Without camera equipment; 40 cm high x 38 cm deep x 18 cm wide (15.8" x 15 x 7.1") (Height with 35 mm camera mounted on photo tube is approximately 51 cm. Height with video camera mounted on photo tube is estimated to be 62 cm (24.4").)

E.I. 126 MICROSCOPE, COMPOUND (continued)  
(E.U. 1 VISUAL RECORDS AND MICROSCOPY)

Envelope Volume:	27.4 dm <sup>3</sup> (0.97 ft <sup>3</sup> ) (without cameras)
Power:	15 watts (estimated) 28 volts d.c.
Data Management:	No instrumentation requiring sampled data monitoring is anticipated. The video camera signal must be transmitted to ground via the Spacelab CDMS.
Heat Rejection:	15 watts (to air)

Development Time: 6 months



STANDARD 18 transmitted-light research microscope for brightfield, darkfield and phase contrast.

E.I. 126A MICROSCOPE, DISSECTING  
(E.U. 4 - Preparation and Preservation Unit)

Purpose

To permit dissection of biological specimens such as plants, animal tissue and organs.

Requirements

Stereo eyepiece head.  
Adjustable light and dark field illumination.

Several desirable optional features have been noted by scientists. These features included a swinging arm mount, photographic capability, and video camera coverage for real time transmission to ground. These features may be implemented by add-on equipment to the microscope described below.

Hardware Status

Rating: Modification.

Commercial units are available which should be usable with minor modifications. A Wild, M5 Stereomicroscope is a high quality, rugged microscope and is recommended for use. Many attachments are available for varied requirements which may arise in the future. The Wild M5 stereomicroscope contains a built-in four-step magnification changer and is more rugged than a similar Wild M7 model with a zoom magnification changer. Although the zoom system is more convenient, it is more easily misaligned under vibration and shock loads, and was therefore not selected for use.

Technical Description

The Wild M5 Stereomicroscope can be set up with various stands, stages, objectives, and photomicrographic attachments, depending upon the particular experiment requirements. Several pictures of the basic M5 Stereomicroscope are attached. It can be set up to use reflected or transmitted light. Estimated weight, power and volume for a typical set-up for flight are given below:

Weight:	9 kg (20 lb)
Volume:	28 dm <sup>3</sup> (1 ft <sup>3</sup> )
Power:	100 watts (12 volt d.c. qtz halogen lamp)
Heat Rejection:	100 watts (special cooling provisions may be required)

E.I. 126A (Cont'd)

Data Management:

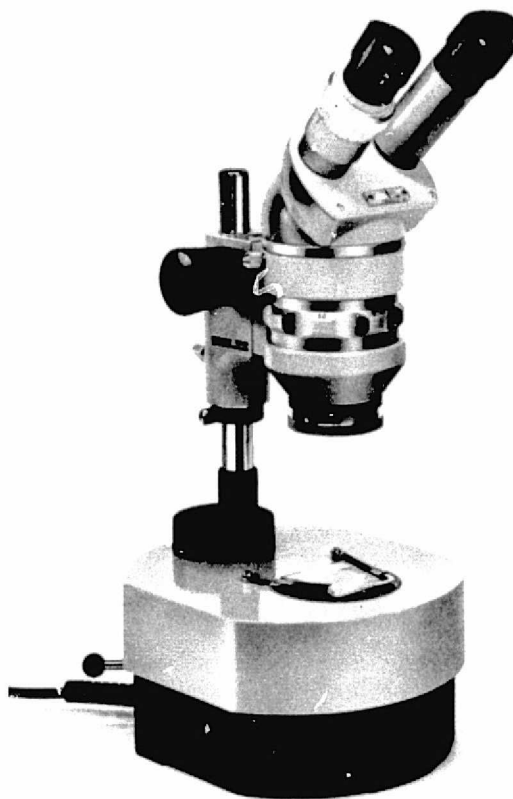
No data monitoring is anticipated. If a video camera is used to monitor experiment procedures, it will require hard line connection to the CDMS for transmission to ground.

Location:

The microscope should be mounted in the general vicinity of the other preparation and preservation equipment (E.U. 4). It might also be accommodated on the Work and Surgical Bench (E.I. 188, E.U. 5).

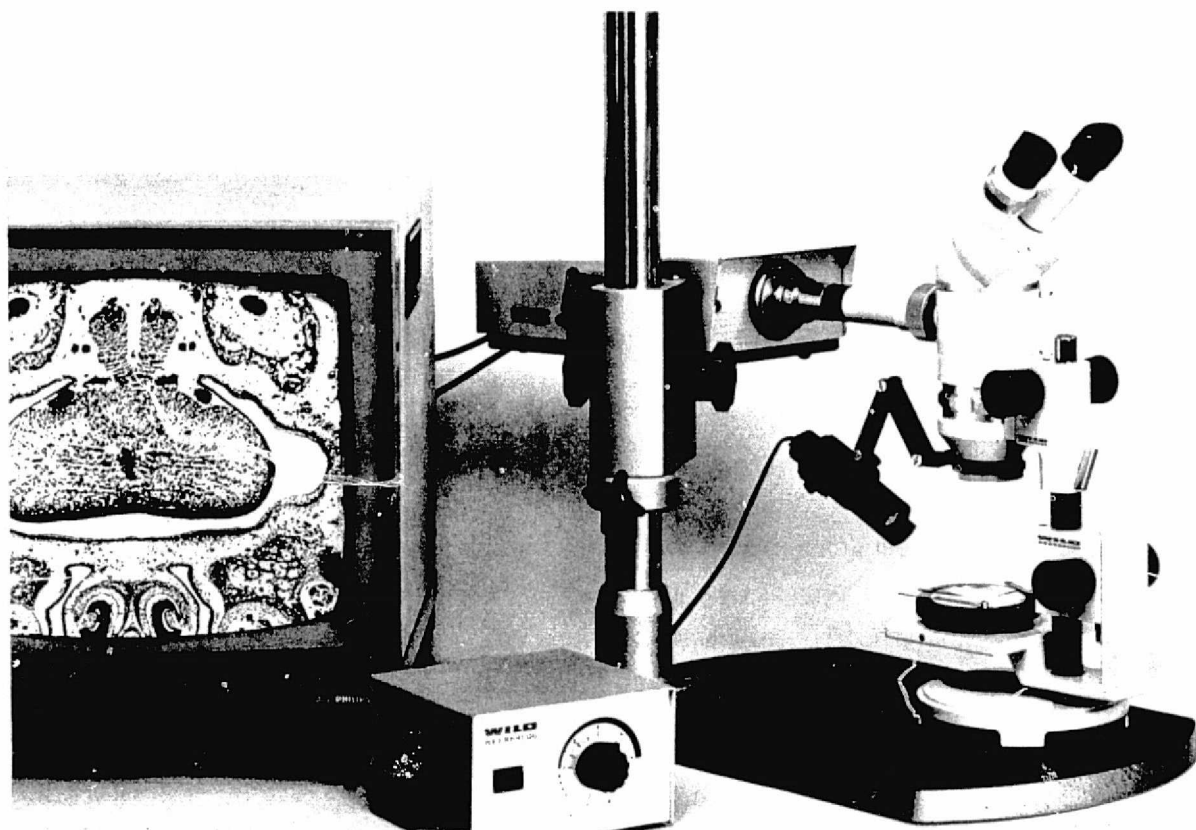
Development Time: 6 months

*M5 Stereomicroscope on incident-light stand.*



*M5 Stereomicroscope on transmitted-light stand for bright and dark field.*

*M5 Stereomicroscope, trinocular assembly, with hand-focussed stage carrier, television phototube Hz, multipurpose camera stand and Philips compact TV camera with monitor.*



E.I. 126I MOBILITY UNIT, PROTECTIVE CORRIDOR  
(E.U. 93 - Mobility Unit)

Purpose

A device to allow mobility and cargo handling studies within the confines of the space vehicle without risk of damaging permanently installed hardware.

Configuration would vary from simple protective covers, bumpers, restraining tethers, etc., for mini-lab missions to an elaborate expandable fully instrumented "tunnel" for the future dedicated laboratory missions.

Requirements

Protect existing hardware within the space vehicle interior from potential damage by out of control test masses, etc.

Provide attachment points for a variety of experimental mobility and cargo-handling aids.

Provide instrumentation to allow sensing of forces and accelerations experienced during a test session.

Hardware Status

Rating: Redesign.

Equipment must be specially designed and built.

Technical Description

Estimated values for early missions are:

Weight:	22.7 kg (50 lb)
Power:	0 watts
Volume:	56.6 dm <sup>3</sup> (2 ft <sup>3</sup> )

Development Time: 18 months.

E.I. 126J MICROSCOPE ACCESSORY KIT, COMPOUND  
(E.U.1 VISUAL RECORDS AND MICROSCOPY)

Purpose

This kit provides a variety of accessories for the Microscope, Compound (E.I. 126, E.U.1).

Requirements

The compound microscope will be required to provide still photography, video photography, bright and dark field illumination, polarizing illumination, and phase contrast illumination.

The attachments or accessories required for this work are included in this kit, and are intended for use with the Zeiss Standard 18 microscope. This kit also includes general purpose items such as lens tissue, spare bulbs, immersion oil, etc., for the operation and maintenance of the compound microscope.

Hardware Status

Rating: Modification

Commercial equipment should be usable with modifications and special packaging. Similar optical equipment including a microscope, have been flown aboard past space flights without undue problems. Glass parts will require protective covers, bags, and packaging. Optically aligned equipment will require proper vibration isolation mounting during handling and launch. Immersion oil was carried aboard Skylab and can be dispensed from a squeeze bottle and cleaned up with wipes.

Technical Description

The accessories described below will make possible the photographic coverage and various types of microscopy specified under the requirements paragraph above. However, all of the accessories listed will probably not be needed for any one mission. Thus, the kit will be made up of only those items required for the particular mission. Also, some of the accessories may be mounted to the microscope rather than stowed in the kit, depending upon the experiments. Zeiss offers a large variety of accessory equipment for their Standard microscopes which is available to the scientist, only a small part of which is listed below.

E.I. 126J MICROSCOPE ACCESSORY KIT, COMPOUND  
(E.U. 1 VISUAL RECORDS AND MICROSCOPY)

<u>Item</u>	<u>Zeiss Cat. Number</u>
1. Polarizing Equipment	
a. Polarizing Filter	473000
b. Screw-in Tube Analyzer	473651
c. Objectives	tbd
2. Camera Attachments (for use with the 35mm camera, E.I. 36, E.U. 1)	
a. Basic Body I	476010
b. Focusing Eyepiece	476025
c. Objective Lens in mount	476025-ou34
d. Ikophot M exposure meter	474202
e. Complan eyepiece Kpl 8 x	463920
f. Adapter for Nikkor F (Bayonet)	476069
3. TV Camera Equipment (for TV camera with standard C thread)	
a. Automatic diaphragm light control	467846
b. Three way beam splittler	473051
c. TV Tube, short	477902
d. Adapter with pointer	477921
4. Phase Contrast Accessories	
a. Centering Telescope	464820
b. Phase contrast objectives	tbd
5. Miscellaneous filters, spare parts, bulb, immersion oil, wipes, etc.	tbd

A kit containing typical accessories for a single dedicated 30-day Life Sciences Laboratory mission was assumed to have the following properties:

Weight:	10 kg (22 lb.)
Volume (stowed):	25 dm <sup>3</sup> (0.88 ft <sup>3</sup> )
Power:	15 watts
Heat Rejection:	15 watts
Data Management:	The major requirement is the recording and/or transmission of video data to ground. The video camera E.I. 38, E.U. 1 will be used in conjunction with the compound microscope and its accessories.
Location:	The compound microscope kit should be placed near the microscope.

Development Time: 6 months

E.I. 132 OSCILLOSCOPE AND CAMERA  
(E.U. 2 - Data Management Unit)

Purpose

To measure and display voltage and electrophysiological signals throughout the laboratory.

Requirements

Desirable features of the oscilloscope include the following:

1. Dual trace capability for signal comparison.
2. Image storage for subsequent comparison and photography.
3. Portability.
4. A camera attachment for production of hard copy data for use during the flight.

Note: Some functions of the Oscilloscope and Camera can be provided by the Strip Chart Recorder (E.I. 150A, E.U. 1). Thus, both equipment items will not always be needed on all missions. Either can be deleted as desired.

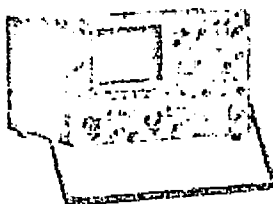
Hardware Status

Rating: Modification

Commercial oscilloscopes should be usable with some modifications. For this study, a Tektronix Model 434 was chosen for use. This dual trace oscilloscope has image storage capability of up to 4 hours, and can be supplied with a standard camera adapter. It is portable and a battery pack is available for use.

An oscilloscope was one of four equipment items tested by Beckman Instruments, Inc., to determine the applicability of off-the-shelf equipment in a spacecraft environment. The results of these tests are reported in the reference cited at the end of this write-up. Beckman tested a Tektronix portable oscilloscope, Model 485, which is similar to the Model 434 in size, appearance and function. The attached table indicates the results of their tests, which verified that the oscilloscope was generally compatible with the Spacelab environment. As indicated in the table, however, two areas require major modification. The major problem identified was the possible explosion of the cathode ray tube upon exposure to space vacuum, which could occur in the event of a

## TERTRONIX 485 OSCILLOSCOPE



## ELECTRICAL

		INSURMOUNTABLE PROBLEM	MAJOR IMPACT ON MISSION GOALS	DESIGN MODIFICATION REQUIRED	MANUFACTURING MODIFICATION REQUIRED	POST-MANUFACTURING MODIFICATION REQUIRED	NO MODIFICATION REQUIRED
POWER CONVERSION							X
POWER DISSIPATION							X
SUSCEPTIBILITY TO EMI							X
EMISSION OF EMI	*						
GROUNDING							X
HUMIDITY	*						

## THERMAL

HOT SPOTS (PERSONNEL SAFETY)							X
HOT SPOTS (COMPONENT FAILURE)							X
TOTAL HEAT LOAD							X
HEAT TRANSFER							X

## CHEMICAL

FLAMMABILITY	*						
OUTGASSING							X

## MECHANICAL

VIBRATION					X	
SHOCK					X	
ACCELERATION					X	
SAFETY					X	
MOUNTING					X	
STORAGE					X	
PROTECTION					X	
MASS						X
SIZE						X
GRAVITY-DEPENDENT COMPONENTS						X

## OPERATIONAL

SOURCE HANDLING						X
CALIBRATION						X
SERVICE						X
HUMAN FACTORS						X

## INTERFACE

MECHANICAL					X	
THERMAL						X
ELECTRICAL				X		
VACUUM			X			

\* REQUIRES FURTHER EVALUATION.

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Beckman Space Application Test Results ORIGINAL PAGE IS POOR

Spacelab decompression. Another problem in the area of electrical properties was that of arcing in the high voltage section when exposed to low pressure, dust, or high humidity. Failure of the instrument occurred as a result of arcing due to the low pressure. The areas of EMI emission, humidity (in excess of 95%), and flammability were reported to require further study.

Although the Tektronix Model 434 is described herein, oscilloscope technology is advancing rapidly and more applicable models may be available in the near future. A new Tektronix storage oscilloscope, Model 466, has recently been made available. It, as well as other makes and models, should be considered in future studies.

#### Technical Description

Information and data on the Tektronix Model 434, is contained in the attached catalog sheets. Also described is a camera attachment (C-30A-P) for the oscilloscope. A battery pack (Model 1105) is also available for this oscilloscope but weighs 8.8 kg (19.4 lb) and was considered too heavy for inclusion. Operation of the oscilloscope at various locations within the laboratory, such as at the Work and Surgical Bench (E.I. 188, E.U. 4), will require electrical connections at these locations.

#### Weight:

Oscilloscope	9.4 kg (20.8 lb)
Camera	2.3 kg (5 lb)
Total	11.7 kg (25.8 lb)

#### Dimensions:

Oscilloscope	33 cm W × 14.2 cm H × 47.5 cm D (13" W × 5.6" H × 18.7" D)
Camera	19.1 cm W × 13 cm H × 26.4 cm D (7.5" W × 5.1" H × 10.4" D)

#### Envelope Volume:

Oscilloscope	22.3 dm <sup>3</sup> (0.79 ft <sup>3</sup> )
Camera	6.6 dm <sup>3</sup> (0.23 ft <sup>3</sup> )

#### Power:

75 watts maximum, 100 to 240 volt,  
50 to 400 Hz

#### Heat Rejection:

75 watts to air

E.I. 132 (Cont'd)

Data Management:

No CDMS monitoring of the oscilloscope is anticipated. Various equipment which the oscilloscope will be used to monitor may be connected to the CDMS.

Location:

The oscilloscope will be mounted in a Space-lab rack. It should be operable, either in the rack or at remote locations throughout the laboratory as required. The camera can be stored in a convenient storage compartment.

Interfaces:

Electrical power system connections should be available at several locations in the laboratory. The oscilloscope hold-down devices must be compatible with Spacelab equipment as well as such equipment items as the Work and Surgical Bench (E.I. 188, E.U. 4).

Operations:

Movement of the oscilloscope and camera around the laboratory as required should be provided for. Safety precautions and guards may be needed to protect the crew from high voltages internal to the unit. Refer to the cited reference for more information.

Development Time: 6 months

Reference

Analysis of Multipurpose Equipment for Space Application, Contract No. NAS8-29776 (NASA/MSFC), Beckman Instruments, Inc., Advanced Technology Operations, 10 December 1973.

**25-MHz Dual-Trace Oscilloscope**  
**25-MHz Dual-Trace Bistable Storage Oscilloscope**

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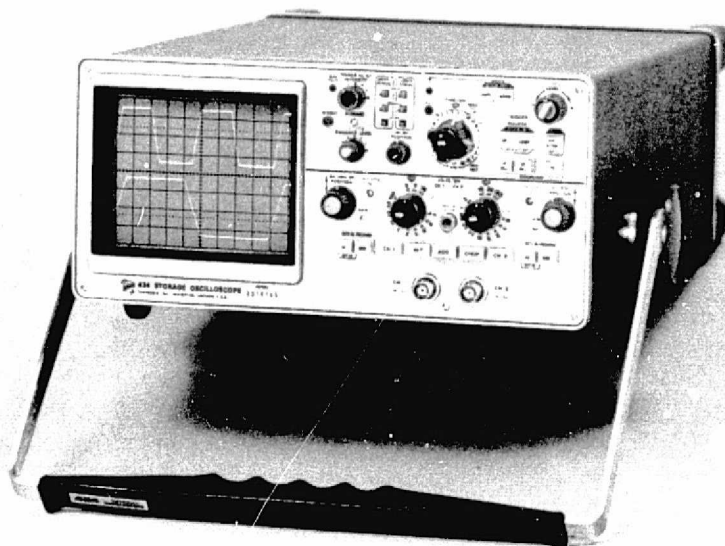
**DEFLECTION FACTORS to 1 mV/DIV**

**LIGHTED KNOB SKIRTS for VOLTS/DIV  
 READOUT, AUTOMATICALLY CORRECTS  
 for 10X PROBES**

**DIRECT-READING WIDE-RANGE MAGNIFIER**

**20 $\frac{3}{4}$  LB**

**5 $\frac{1}{4}$ -INCH RACKMOUNT**



The 432 and 434 have identical performance characteristics, except the 434 has a bistable storage CRT. These dual-trace oscilloscopes with bandwidth to 25 MHz, sweep rates to 20 ns/div and deflection factors to 1 mV/div cover a wide range of laboratory and field applications. Both instruments are small and light. Cabinet height is 5 $\frac{3}{4}$  inches including the feet, (rackmount height is 5 $\frac{1}{4}$  inches) and weight is 20 $\frac{3}{4}$  pounds. Applications include field maintenance areas where conventional AND storage capability are needed. Laboratory and engineering applications areas include electrical, mechanical and civil engineering, medicine, education, acoustics, biology, chemistry, forestry, oceanography and many others. Small size makes it easy to take these instruments to the field as well as carry them from one laboratory to another.

The retention feature of the 434 storage CRT is useful for displaying many kinds of signals, especially single and low repetition rate events. Signals with repetition rates low enough to cause flicker are usually very distracting. Storage displays these signals at a constant light level. With storage, the operator can obtain displays of aperiodic or random events quickly and easily. Once the signal of interest is located and stored, the display can be photographed for high quality, permanent records.

The 434 displays stored events in a view mode for as long as four hours at constant intensity and resolution. This permits the operator to view the event as it's displayed, and study it as long as necessary at his convenience. When interruptions occur he's free to leave the stored display for extended periods without being concerned that the trace might degrade or lose resolution.

Split-screen storage operates in each of three modes: full-screen storage, or upper (or lower) screen storage with the other half in a conventional mode. Events stored on the upper (or lower) area are stable reference points for events displayed in a conventional mode on the other half of the CRT.

The split-screen storage CRT provides the convenience of storage and conventional displays on the same CRT at the same time. This capability is useful in many applications. For instance, the operator may wish to store a reference trace and then view the change in waveform characteristics as he varies circuit components. He does this easily by operating half of the display in a stored mode and the other half in a conventional mode. Thus, amplitude, duration, and other characteristics of waveforms displayed in a conventional mode can be adjusted precisely to the stored reference trace.

Comparison of changing phenomena is easily made using the TEKTRONIX unique split-screen storage CRT. In measurement of pulse response as a function of temperature, for example, a reference display can be stored on the upper screen area, then compared with subsequent displays stored on the lower screen area. The effect of the temperature change is easily seen. After studying the pulse changes, the user can erase either half of the screen and store a third display under still different conditions. This procedure can be repeated as often as needed. The operator presses one button to erase the upper half of the CRT and a second button to erase the lower half. Pressing both buttons simultaneously erases the full screen.

The writing speed of the bistable storage CRT is variable from 100 div/ms to 400 div/ms on the 434. Option 1 increases the normal writing speed to 500 div/ms and to 5000 div/ms in enhanced operation. This allows the user to choose the writing rate best suited for his requirements.

The design of the TEKTRONIX storage CRT makes it highly resistant to burrs. It requires only the same operating care as a conventional CRT.

Vertical scale-factor readout is provided by lighted knob skirts which automatically indicate the correct reading, even when using the recommended 10X probes. This feature saves time and reduces errors by freeing the user from having to calculate the scale factor each time a measurement is made with the 10X probes.

## 25-MHz Dual-Trace Oscilloscopes

### 25-MHz Dual-Trace Bistable Storage Oscilloscope

#### 434 STORAGE

**TEKTRONIX Storage CRT**—5-inch rectangular tube, 8 x 10 div (1 div = 0.98 cm) display area. Phosphor is similar to P1. 4-kV accelerating potential.

**Graticule**—Internal, parallax-free, nonilluminated.

**Split-Screen Storage**—3 Display Modes: Storage on either upper or lower half of screen with conventional display on either half. Storage on entire screen or conventional display on entire screen. Independent operation of both halves.

**Writing Speed (Center 8 div)**—Normal, 100 div/ms. Enhanced increases single-sweep storage writing speed to at least 400 div/ms. (Option 1, 500 div/ms, normal; to 5000 div/ms, enhanced).

**Storage Viewing Time**—Up to four hours

**Erase Time**—300 ms or less

#### CHARACTERISTICS

The following characteristics apply to both the 432 Oscilloscope and 434 Storage Oscilloscope, except where noted:

##### VERTICAL DEFLECTION (2 Identical Channels)

**Deflection Factor**—1 mV/div to 10 V/div in 13 calibrated steps (1-2-5 sequence), accurate within 3%. Lighted knob skirts indicate correct deflection factor for either 1X or 10X probes. Uncalibrated, continuously variable between steps and to approx 25 V/div.

**Bandwidth and Rise Time**—(from 50- $\Omega$  terminated source, with or without 10X probe) DC to at least 25 MHz at 3-dB down\*, 14 ns from 10 mV/div to 10 V/div, decreasing to 15 MHz, 22 ns at 1 mV/div. Low-frequency 3-dB down point with AC coupling is 14 Hz or less (less than 1 Hz with 10X probe).

**Display Modes**—Channel 1 only. Channel 2 only (normal or inverted); Alternate; Chopped (approximately 100 kHz). Added.

**Input R and C**—1 megohm  $\pm$  2% paralleled by approx 24 pF.

**Maximum Input Voltage**—DC coupled: 250 V (DC plus peak AC), AC coupled: 500 V (DC plus peak AC). In either mode the maximum AC is 500 V P-P at 1 kHz or less.

**Delay Line**—Permits viewing of leading edge of triggering waveform.

**Internal Trigger Source**—Composite (displayed signals) or Channel 1 signal only.

##### HORIZONTAL DEFLECTION

**Time Base**—0.2  $\mu$ s/div to 5 s/div in 23 calibrated steps (1-2-5 sequence). Uncalibrated, continuously variable between steps and to 12.5 s/div. Accurate within 3% unmagnified and 4% magnified from  $\pm$  20°C to  $\pm$  30°C, within 4% unmagnified and 5% magnified from  $\pm$  15°C to  $\pm$  55°C.

**Direct Reading Magnifier**—Six-position, push-to-turn, 50X maximum. Extends fastest sweep rate to 20 ns/div.

**Time Base Sweep Modes**—Auto Trigger. (sw on free runs in absence of triggering signal and provides bright baseline at all sweep rates). Normal Trigger, Single Sweep.

**External Horizontal Input**—Deflection factor is approx 0.5 V/div. Input resistance is approx 50 k $\Omega$ .

#### TRIGGER

COUPLING	TO 5 MHz		AT 25 MHz
	INTERNAL	0.3 div deflection	1 div deflection
OC	EXTERNAL	50 mV	175 mV
AC		Same as DC at 20 Hz and above, requirements increase below 20 Hz	
AC LF REJECT		Same as AC at 50 kHz and above, requirements increase below 50 kHz	
AC HF REJECT		Same as AC at 50 kHz and below, requirements increase above 50 kHz	

**Sources**—Channel 1 only, composite, line, external and external to Input R approximately 1 megohm. Maximum external input, 250 Volts (DC  $\pm$  peak AC). External trigger level range is at least  $\pm$  2 V to 2 V or  $\pm$  20 V to 20 V.

#### 432 CRT

**TEKTRONIX CRT**—5-inch rectangular tube, 8 x 10 cm display area. P31 phosphor normally supplied. P7 is optional without extra charge. 4-kV accelerating potential.

**Graticule**—Internal, parallax-free, nonilluminated.

#### ENVIRONMENTAL CAPABILITIES (Oscilloscope and Probe)

**Ambient Temperature**—Operating, 15°C to  $\pm$  55°C. Storage, 55°C to  $\pm$  75°C.

**Altitude**—Operating, 15,000 feet. Maximum allowable operating temperature decreases 1°C/1000 feet from 5,000 to 15,000 feet.

**Vibration**—Operating and non-operating, 15 minutes along each of the three major axes at a total displacement of 0.075 inch P-P (4 g's at 55 Hz) with frequency varied from 10 to 55 to 10 Hz in 1-minute sweeps.

**Shock**—Operating and non-operating, 30 g's, 1/2 sine, 11-ms duration, 2 shocks per axis in each direction for a total of 12 shocks.

**Electromagnetic Interference**—With the optional mesh filter (378-0682-00) installed the 432 and 434 meet interference requirements of MIL-1-6181D. Conducted, 150 kHz to 25 MHz. Radiated, 150 kHz to 1 GHz.

**Humidity**—Operating and storage, 5 cycles (120 hours) to 95% relative humidity referenced to MIL-E-16400F (par 4.5.9 through 4.5.9.5.1, class 4).

#### OTHER CHARACTERISTICS

**Locate**—When the 434 is operated in the stored mode, the beam can be positioned to the left of the graticule area to determine the vertical position of the next sweep without disturbing a stored display.

**Beam Finder**—Compresses display to within graticule area independent of position controls or input signal amplitude, for ease in determining the location of an off-screen signal.

**Z Axis**—Input DC coupled to CRT, noticeable modulation at normal intensity with 5 volts or more P-P, DC to at least 20 MHz.

**Amplitude and Time Calibrator**—0.6 V adjustable within 1.0%. Repetition rate is adjustable to 1 kHz within 1.0% ( $\pm$  20°C to  $\pm$  30°C). Output resistance is 575 ohms.

**Power Requirements**—Operates without range switching on all voltages from 100 V to 240 V, 50 to 400 Hz, 00 VA (55 w) max (432), 120 VA (75 w) max (434). Also operates from 105 VDC to 250 VDC.

Dimensions	Cabinet		Rackmount	
	In	cm	In	cm
Height	5.6	14.2	5.3	13.3
Width with handle	13.0	33.0	19.0	48.3
Depth	18.7	47.5	18.0	45.7
Weight (approx)	lb	kg	lb	kg
Net weight	20.8	9.4	23.1	10.5
Domestic shipping	30.0	13.6	42.6	19.4
Export-packed	35.0	15.9	62.6	28.4

**Included Accessories**—Two P6061 3.5-ft probes with accessories (010-0081-01), accessory pouch (016-0165-00).

#### ORDERING INFORMATION

432 OSCILLOSCOPE	\$1585
434 STORAGE OSCILLOSCOPE	\$2150
434 STORAGE OSCILLOSCOPE (Option 1)	\$2175
RA32 OSCILLOSCOPE (Rackmount model)	\$1625
RA34 STORAGE OSCILLOSCOPE (Rackmount model)	\$2150
RA34 STORAGE OSCILLOSCOPE (Rackmount model, Option 1)	\$2215

#### OPTIONAL ACCESSORIES

Optional accessories increase measurement capability and provide added convenience. The standard probes supplied with these oscilloscopes satisfy most measurement requirements; optional probes, including high voltage and current probes, may be better suited for particular applications. See the accessory pages of this TEKTRONIX catalog.

Mesh Filter—Improves contrast and EMI filtering. Order 378-0682-00	\$15
Portable to Rackmount Assembly—Includes hardware for converting standard 432 and 434 to 19-inch rack installation. Order 016-0272-00	\$80
Folding Polarized Viewing Hood—Order 016-0180-00	\$9
Clear Plastic CRT Filter—Order 378-0677-00	\$50
Camera Adapter—Mounts C-30A Series Camera to the 432 & 434 Oscilloscope. Order 016-0301-00	\$35

**SCOPE-MOBILE Cart**—Occupies less than 10 inches aisle space, has storage area in base. Order 200-1B. \$120

\* Bandwidth operating to 22 MHz at temperatures above  $\pm$  30°C

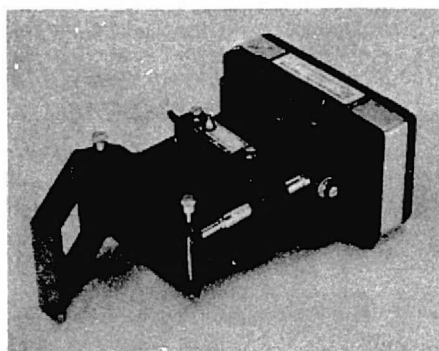
U.S. Sales Prices FOB Beaverton, Oregon

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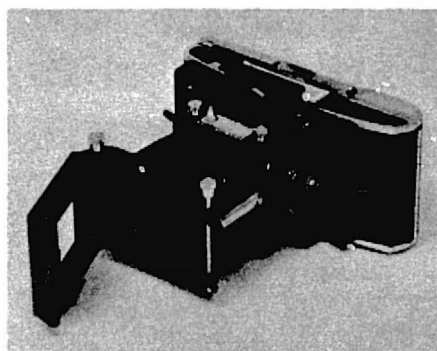
# CAMERAS C-30 Series

## COMMON FEATURES

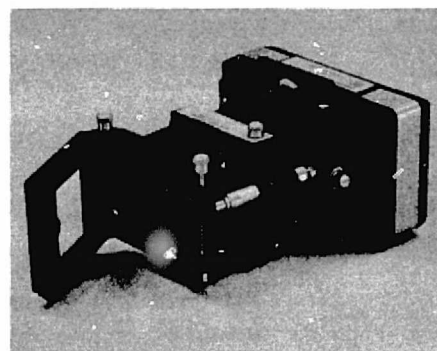
- COMPACT, LIGHTWEIGHT
- EASILY-ACCESSIBLE CONTROLS
- OPTIONAL ELECTRIC SHUTTER AND SPEEDCOMPUTER



C-30A



C-31



C-32

The C-30-Series Cameras are recommended primarily for the TEKTRONIX 400-Series Portable Oscilloscopes. They can also be used with many other TEKTRONIX Oscilloscopes and Display Units by means of adapters listed on page 213.

The standard C-30A, and the C-31 and C-32 are supplied with an 016-0360-00 Adapter which allows the camera to slide-mount directly onto the 422, 453A, 454A, and 485 Oscilloscopes and the 491 Spectrum Analyzer; all these instruments have an 8 x 10 division CRT display (0.8 cm/div).

The C-30A can also be ordered as an Option 1 Model which comes equipped with an 016-0301-00 Adapter Frame/Corrector Lens to allow its use on the 432, 434, 465, and 475 Oscilloscopes<sup>1</sup>. The Adapter Frame/Corrector Lens increases the C-30A's field-of-view so it can photograph the entire 8 x 10-cm CRT display of these oscilloscopes; the 434 CRT display is actually 7.8 x 9.8 cm but it also requires the Option 1 Model of the C-30A for full-screen coverage.

The C-30A Option 1 can also be used with any standard C-30 Series Camera Adapter by simply removing the Corrector Lens which is normally mounted over the front of the camera's lens. A standard C-30A Camera can also be converted to an Option 1 Model by means of an 016-0301-00 Adapter Frame/Corrector Lens as listed on page 213.

No Adapter Frame/Corrector Lens assemblies are available for allowing use of the C-31 and C-32 Cameras with the 432, 434, 465, and 475 Oscilloscopes.

All C-30-Series Cameras swing open left or right, and can be quickly detached from the adapter at the hinges. All cameras can be ordered with an integral Electric Shutter in place of the standard mechanical shutter; these "E" model cameras include a SPEEDCOMPUTER control box which supplies operating power to the electric shutter.

## SUMMARY COMPARISON OF MAJOR CHARACTERISTICS

CAMERA	C-30A	C-30A OPTION 1	C-31	C-32				
PERFORMANCE FEATURES	General Purpose with variable magnification for 422, 453A, 454A, 485 and 491	General Purpose for 432 <sup>1</sup> , 434, 465 and 475 oscilloscopes	Fast Writing Speed with 0.5 Magnification for 422, 453A, 454A, and 485 oscilloscopes	Full-Size Image with Medium Writing Speed for 422, 453A, 454A, 485 and 491				
LENS	f/1.9	f/1.9	f/1.2	f/1.4				
MAGNIFICATION	1.5 to 0.7 in ten detent steps	0.8 only with corrector lens. (lens can be removed for normal C-30A MAG Range)	0.5 fixed	1.0 (detent steps also at 0.85, 0.9, 1.1 and 1.2 but with some distortion)				
RELATIVE LENS SPEED*	1.0 at MAG setting of 0.7	1.0	3.4	1.5				
FIELD OF VIEW	8 x 10 cm at MAG setting of 0.85. (Possible corner vignetting with some instruments)	8 x 10 cm	8 x 9 cm	7 x 9 cm at MAG setting of 1.0 (increases to 8 x 10 cm at MAG setting of 0.85 but with some distortion)				
STANDARD SHUTTER	Mechanically actuated, 4 to 1/50 sec, plus Bulb and Time.							
OPTIONAL ELECTRIC SHUTTER	Speeds: 4 to 1/60 sec, plus Bulb and Time. Remote triggering with insulated switch closure. Power requirements: 115, 230 v, 50 to 60 Hz. See next page for ordering information.							
FILM BACKS	All cameras can be ordered with a Polaroid <sup>2</sup> Pack Back for 3,000-speed film, a Polaroid Roll Back for 3,000- and 10,000-speed film, or a 2 1/4 x 3 1/4-inch Graflok <sup>3</sup> Back for sheet film holders, film pack adapters and 120 roll film holders such as listed on preceding page.							
PRICE (With Film Back Ordinarily Used)	\$525 (With Pack Back)	\$535 (With Pack Back)	\$675 (With Roll Back)	\$715 (With Pack Back)				
DIMENSIONS AND WEIGHTS WITH FILM BACKS ORDINARILY USED								
	C-30A-P		C-30A-P Option 1		C-31-R		C-32-P	
	Inches	cm	Inches	cm	Inches	cm	Inches	cm
Height	5.1	13.0	5.1	13.0	5.5	14.0	5.5	14.0
Width	7.5	19.1	7.5	19.1	9.1	23.1	7.5	19.1
Length	10.4	25.4	10.4	26.4	10.6	26.9	10.0	25.4
Weight (approx)	lb	kg	lb	kg	lb	kg	lb	kg
Net	4.8	2.2	5.0	2.3	6.8	3.1	5.0	2.3
Domestic Shipping	9.0	4.1	9.0	4.1	12.0	5.4	9.0	4.1
Export-Packed	14.0	6.4	14.2	6.4	17.0	7.7	14.0	6.4

\*Relative light gathering power—(See Camera Reference Information for comparison of all TEKTRONIX cameras)

<sup>1</sup>The internal graticule in the 432, and 453A Models 1, 2, 3, and 4 is non-illuminated and thus is not photographable. The 434 graticule is also nonilluminated, but it will photograph when the CRT is in the stored mode.

<sup>2</sup>Registered Trademark, Polaroid Corporation.

<sup>3</sup>Registered Trademark, Graflex, Inc.

E.I. 134B PAPER, RECORDING  
(E.U. 1 - Visual Records & Microscopy Unit)

Purpose

For use with the Recorder, Strip Chart (E.I. 150A, E.U. 1).

Requirements

Paper is for the Brush Recorder No. 222, Gould, Inc.

Hardware Status

Rating: Repackage.

The standard Brush recorder paper rolls should be usable.

Technical Description

The reproducible type of chart paper for the Brush 222 recorder was assumed for use in the life sciences laboratories. The paper has two 40 mm grids (one for each pen) with 50 divisions per grid. Lengthwise, the paper is divided into millimeters and each roll contains 122 meters (400 ft). The estimated properties of each roll are:

Weight:	0.6 kg (1.3 lb)
Envelope Dimensions:	10 × 10 × 12 cm (4 × 4 × 4.7 inches)
Envelope Volume:	1.2 dm <sup>3</sup> (.042 ft <sup>3</sup> )
Power & Heat Rejection:	0
Location:	Store near Recorder, Strip Chart (E.I. 150A, E.U. 1)

Development Time: None

E.I. 138 pH METER  
(E.U. 5 Biochemical and Biophysical Analysis Unit.)

Purpose

This meter or sensor measures the hydrogen ion concentration of solutions.

Requirements

To be determined.

Hardware Status

Rating: Modification

Meters for ground use are readily available and should be adaptable to zero-g. Modifications will involve 0-g liquid containment techniques, compatible 0-g sensor design, and alteration for use of 28 volt d.c. power. Also, these units could be made to operate in conjunction with a general purpose display console. Two Orion commercial pH meters with digital readouts are shown in the attached catalog sheet. Another source of good quality pH meters, according to UCSD scientists, is The Radiometer Co. of Copenhagen.

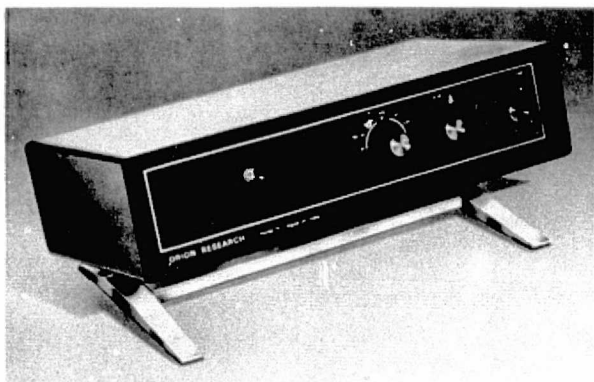
Technical Description

Based on the Orion Model 701, the estimated properties of a flight type pH meter are:

Weight	1.8 kg (4 lb)
Size	32.7 cm wide × 17.8 cm deep × 8.9 cm high (12-7/8" × 7" × 3-1/2")
Volume	5.2 dm <sup>3</sup> (0.18 ft <sup>3</sup> )
Power	20 watts (115 volt, 60 Hz)

Development Time: 6 months

## E.I. 138 pH METER (CONT.)



H5795

### H5795

**pH METER, Orion Model 701 (Orion 070100)**—For general purpose applications requiring measurements in pH and millivolts in the standard and expanded modes. Unit offers bright 4-digit Nixie tube digital display of results; automatic over-range display blanking. Amplifier drift is less than 0.001 pH/°C; recorder output is 0 to  $\pm 100$ mv for full scale deflection. Circuitry permits BCD output. Complete with electrode holder and rod, and shorting strap; without temperature probe or electrodes. Dimensions:  $12\frac{7}{8}$ "w  $\times$  7"d  $\times$   $3\frac{1}{2}$ "h. For operation on 115/230V, 50/60 Hz, 20 watts.

#### SPECIFICATIONS

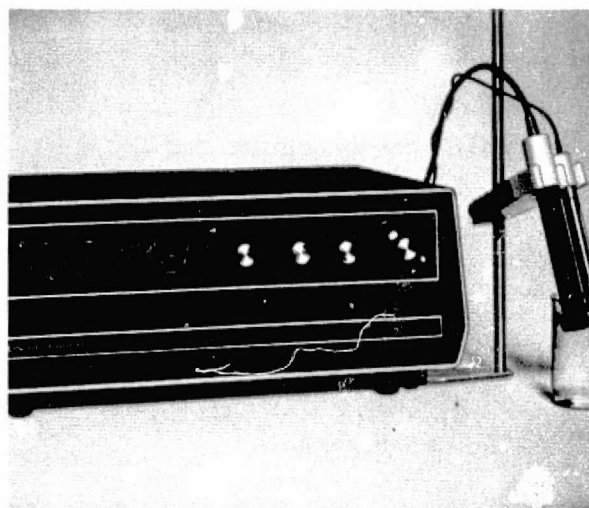
Scale	Normal	Expanded
Range	0-14 pH; $\pm 1999$ mv	2 pH; $\pm 199.9$ mv
Accuracy	$\pm 0.01$ pH; $\pm 0.1$ mv	$\pm 0.001$ pH; $\pm 0.1$ mv
Reproducibility	$\pm 0.01$ pH; $\pm 1$ mv	$\pm 0.001$ pH; $\pm 0.1$ mv
Temp. compensation	0° to 100°C (Automatic)	
Input impedance	$10^{12}$ ohms	

Order **H5795—Model 701** . . . . . Each **\$750.00**

### H5796-1

**TEMPERATURE PROBE (Orion 070110)**—Automatic probe for use with H5795 pH Meter.

Order **H5796-1—Probe** . . . . . Each **\$48.00**



H5800

### H5800

**pH METER, Orion Model 801 (Orion 080100)**—For applications requiring a high degree of precision and accuracy; functions with specific ion, pH, or redox electrodes with level of repeatability necessary for research techniques. Nixie tube digital display is visible for 30 feet; display time is adjustable from 0.6 to 6.0 seconds, or continuous. Display data is available for BCD output for interface; polarity is indicated along with numerical data. Amplifier drift is less than 0.0002/°C; recorder output is adjustable 0 to  $\pm 100$ mv for full scale deflection. Complete with electrode holder and rod, and shorting strap; without electrode. Dimensions:  $18\frac{3}{8}$ "w  $\times$  12"d  $\times$   $6\frac{3}{16}$ "h. For operation on 115/230V, 50/60 Hz, 40 watts.

#### SPECIFICATIONS

Range	0-14 pH; $\pm 999.9$ mv
Accuracy	$\pm 0.002$ pH; $\pm 0.1$ mv
Reproducibility	$\pm 0.002$ pH; $\pm 0.1$ mv
Temp. compensation	0° to 100°C (Manual)
Input impedance	$10^{14}$ ohms

Order **H5800—Model 801** . . . . . Each **\$1095.00**

H5800,  
H5802-1

### H5802-1

**DIGITAL PRINTER, Model 851 (Orion 085100)**—For use with H5800 Model 801 or H5795 Model 701 pH Meters. Unit prints data on standard adding machine tape with capacity of 4 significant figures; may be set to print data alone, adjustably time-indexed, or sequentially numbered. Program may be interrupted at any time without loss of accumulated elapsed time; unit also responds to external signals from titrators, sample changers, and electrode switches. Dimensions:  $15\frac{3}{8}$ "w  $\times$  12"d  $\times$   $5\frac{3}{16}$ "h. For operation on 115V, 50/60 Hz.

Order **H5802-1—Model 851** . . . . . Each **\$1595.00**



E.I. 138B PHOTOCELL COUPLER  
(E.U. 2 - Data Management Unit)

Purpose

To provide power to miscellaneous photo sensors and to transmit photo sensor signals to the CDMS.

Requirements

Photo sensors will be used to monitor on-off light conditions or measure discrete light levels. Photo transistors, light activated SCRs, and light activated switches will probably be used, each with individual couplers designed for their specific applications.

Hardware Status

Rating: Redesign

Existing electronics components and packaging designs should be usable.

Technical Description

Estimated properties of a typical photocell coupler are:

Weight:	0.2 kg (.44 lb)
Volume:	0.5 dm <sup>3</sup> (0.018 ft <sup>3</sup> )
Power:	2 watts
Heat Rejection:	2 watts
Data Management:	Low rate analog or digital signal output to CDMS.
Location:	These couplers will probably be placed in or near the plant or vertebrate holding units, where the photo sensors will most likely be located.
Interfaces:	These couplers will be connected to their respective photo sensors, the EPS, and the CDMS.

Development Time: 6 months

E. I. 139 PLETHYSMOGRAPH, LIMB (INCLUDING COUPLER)  
(E.U. 31 Biomedical Research Support Unit.)

Purpose

To measure changes in blood volume and vascular responses.

Requirements

Determine changes in biological segments that occur during cardiac and breathing cycles.

Hardware Status

Rating: Modification

Commercial equipment should be adaptable for space use.

Technical Description

The following are estimates of a space including sensors, cable, and signal conditions:

Weight	2.4 kg ( 5 lbs)
Volume	6 dm <sup>3</sup> (.2 ft <sup>3</sup> )
Power	5 watts

Development Time: 12 months

## E. I. 141A PLUMBING

(E.U. 3 Life Sciences Experiment Support Unit.)

### Purpose

For liquid and gas transfer and control between equipment items throughout the life sciences laboratory.

### Requirements

Fluid flow rates and line sizes are yet to be determined. In general, it is expected that small lines on the order of 0.64 cm (1/4 inch) o.d. will be sufficient. Fittings, quick disconnects, and valves will also be required. This plumbing is in addition to that required for the Coolant Loop, Liquid (EI 51F, EU 3) and the Atmospheric Sampling System (EI 15A, EU 5).

### Hardware Status

Rating: Redesign

Available flight and commercial hardware should be usable.

### Technical Description

The following estimates were made for general plumbing requirements of 7-day dedicated laboratories.

Weight	20 kg (44 lb)
Volume	15 dm <sup>3</sup> (0.53 ft <sup>3</sup> )
Power	2 watts (valves and controls)

Development Time: 12 months

E. I. 143G PRESSURE COUPLER  
(E.U. 2 Data Management Unit.)

Purpose

To provide power to pressure transducers and condition transducer signals for transmission to the CDMS and other display devices.

Requirements

TBD. Will depend upon the specific pressures being measured.

Hardware Status

Rating: Redesign

Existing components can be used to design couplers for specific sensors and transducers.

Technical Description

Estimated properties of a typical photocell coupler are:

Weight: 0.2 kg (0.44 lb)

Volume:  $0.5 \text{ dm}^3$  ( $0.018 \text{ ft}^3$ )

Power: 2 watts

Heat Rejection: 2 watts

Data Management: The CDMS sampling rate will depend upon the specific application. For physiological pressure monitoring, a maximum rate at 100 samples per second was assumed. (7 bits per sample)

Development Time: 6 months

**E. I. 144 PSYCHOMOTOR PERFORMANCE CONSOLE**  
(E.U. 91 MSI Measurements Unit.)

Purpose:

An integrated test bed for testing various displays and controls and performing a variety of psychomotor measurements such as tracking skills, etc.

Requirements:

1. Provide a reprogrammable test bed for evaluating a variety of display-control configurations.
2. Provide the capability for measuring the following parameters:  
Tracking ability  
Manipulative ability - arm/hand steadiness, finger dexterity  
Gross positioning ability - multilimb coordination, position reproduction/estimation  
Skill maintenance

Hardware Status:

Rating: Redesign

IMBIM's Psychomotor Measurement Assembly may be adaptable for this purpose.

Technical Description:

Estimated values:

Weight:	8.2 kg (18 lb)
Volume:	10.3 dm <sup>3</sup> (0.36 ft <sup>3</sup> )
Power:	15 watts

Development Time: Approximately 24 months

E. I. 144C RADIATION DETECTOR, DOSIMETER  
(E.U. 26 Radiobiology Support Unit.)

Purpose

To provide the crew with a portable device which will alert them to radiation levels in excess of some preset threshold, and to provide a direct readout of the total cumulative radiation dose.

Requirements

Rate Measurement Ranges -

from 0 - 0.1 mr/hr to  
0 - 50 r/hr.

Adjustable Level Radiation Alarm: -

from 0.05 mr/hr to  
50 r/hr.

Cumulative Dosage Ranges:

0 - 200 mr  
0 - 500 r

Measurements to be within  $\pm 10\%$  accuracy on both X-Ray and Gamma radiation. Readout and charging equipment for the cumulative dosage portion of the instrument to be a part of the basic equipment, i.e., self contained.

Equipment Operation and Calibration to be checked by the use of a self-contained radiation standard.

Accessory equipment to include a neutron detector system, utilizing the metering circuits of the basic equipment.

The dosimeter portion of the assembly must be detachable and operable as a separate instrument. These instruments can be used for measuring total dosage to several hundred biological specimens.

Hardware Status

Rating: Re-package

Instruments specifically designed for radiation rate measurements (see attached catalog sheet) or for cumulative dosage measurements are available. Required instrument would combine these two functions and utilize common equipment when possible.

Technical Description (Preliminary)

Weight	0.3 kg (.66 lb)
Envelope Dimensions:	16 x 8 x 4 cm (6.3 x 3.2 x 1.6 inches)
Envelope Volume:	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )
Power:	Self powered, rechargeable (Charger built in; 28 VDC input)

Development Time: 4 months

**FH 40K MINIATURE RADIAMETER** — A fully transistorized universal surveying instrument designed to determine the presence of radioactive material or contamination. It is recognized as a professional instrument and it is built to the highest standards of quality and workmanship. Due to its simplicity in design it is used both as a testing instrument and a training device; the recessed single control knob permits its operation by inexperienced personnel. It has been bought in quantity by the Red Cross, various government, municipal, and public health groups.

Measurements are indicated on the meter scale which is practically logarithmic. With the slideable plastic window removed, one can note both Beta and Gamma radiation. Indication is either by means of the accessory earphone unit or by the direct reading meter scale. It may be used anywhere, indoors or in the field. The plastic carrying case with neck-band has openings for the meter scale, control knob, and earphone connector. Both the instrument and the carrying case are washable; the instrument case is molded of styrene and is splash-proof.

#### TECHNICAL DATA

**ACCURACY** — For Gamma  $\pm 15\%$  throughout scale range of 0-50 mr/h, insensitive to temperature over range of 15-130°F (-10/50°C)

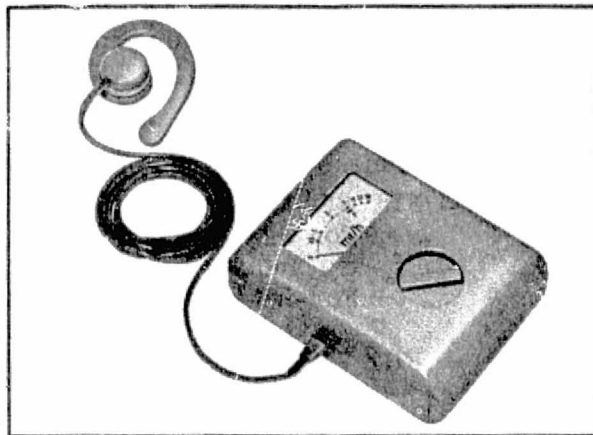
**Differentiation between Beta and Gamma radiation:** Density of Radiation Entrance Window, for Gamma  $\geq 500$  mg/cm<sup>2</sup>. Ditto, with plastic window removed: for Gamma and Beta  $\leq 30$  mg/cm<sup>2</sup>

**BASIC COMPONENTS** — 1 sturdy plastic case containing a stabilized Halogen filled Geiger counter tube, 2 Transistors, 2 Germanium diodes, 1 Selenium high voltage rectifier, 1 high voltage stabilizer, 1 moving coil meter, a single 3-position control knob and 2 batteries.

**POWER PACK** — 2 miniature commercial 1-1/2v batteries (Eveready #904) which give approx. 10 hours continuous service.

**DIMENSIONS** — 4" x 2-7/8" x 1-1/8" (100 x 7 x 30 mm). Weight: 7 oz. (200 g.).

**ACCESSORIES** — Magnetic earphone assembly with cable and plug. Washable plastic carrying case with neck-band.



FH 40K Miniature Radiometer

The Kahl Scientific Instrument Corp., directly or through its agents, can supply other FH high quality instruments, including the unsurpassed Continuous Air Monitor which is now universally used at important research centers, the Continuous Water Monitor, Discontinuous Air Monitor, Methane Flow Counter, Scintillation Counter, Scaler, Ratemeter, Automatic Planchet Changer, Laboratory Monitor, Stationary Air Monitor, Dosage Calculator, Pocket Dosimeter, and other approved instruments. Write for literature.

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E. I. 147 RADIATION COUNTER  
(E.U. 26 Radiobiology Support Unit.)

Purpose

To measure gamma radiation levels in biological samples and specimens.

Requirements

TBD

Hardware Status

Rating: Modification

Commercial equipment should be usable with minor modifications.

Technical Description

Estimated flight unit properties are:

Weight:	15 kg (33 lb)
Volume:	20 dm <sup>3</sup> (0.71 ft <sup>3</sup> )
Power:	50 watts

Development Time: 6 months

**E. I. 150A RECORDER, STRIP CHART**  
(E. U. 1 Visual Records and Microscopy Unit.)

Purpose

To record various analog voltage signals, including electrophysiological measurements. Hard copy records may not be required on all laboratories depending upon the specific experiments.

Requirements

To be determined.

Hardware Status

Rating: Modification

Required modification of commercial units might involve the ink feed system for 0-g operation and the power supply for use with 28 volt d.c. The following technical data was based on the portable commercial unit built by Gould Inc. and described in the attached catalog sheets.

Technical Description

The Gould Inc., Brush Recorder No. 222 has two analog channels and two event channels. It has a pressurized ink feed system which may be compatible with 0-g operation. It is battery powered and has the following weight and volume.

Weight:	11.8 kg (26 lb)
Envelope Dimensions:	23 cm wide x 35 cm high x 21 cm deep (9 x 14 x 8 inches)
Envelope Volume:	16.9 dm <sup>3</sup> (0.60 ft <sup>3</sup> )
Power:	Battery powered. Charging power tbd.

Development Time: 6 months

## BRUSH 222 RECORDER

Now you can get famous Brush quality and performance in a 2 channel general purpose recorder that operates anywhere. The new Brush 222 has an internal battery supply and charger, permitting it to be used away from external power sources as well as from them. Imagine the many additional measurements you can record with this unit — quickly, conveniently, cordlessly. And, when you're not making chart recordings in the self-powered mode, your Brush 222 can serve as a bench or rack mounted unit operating from external a-c or d-c power sources.

The many features of this extremely versatile recorder include:

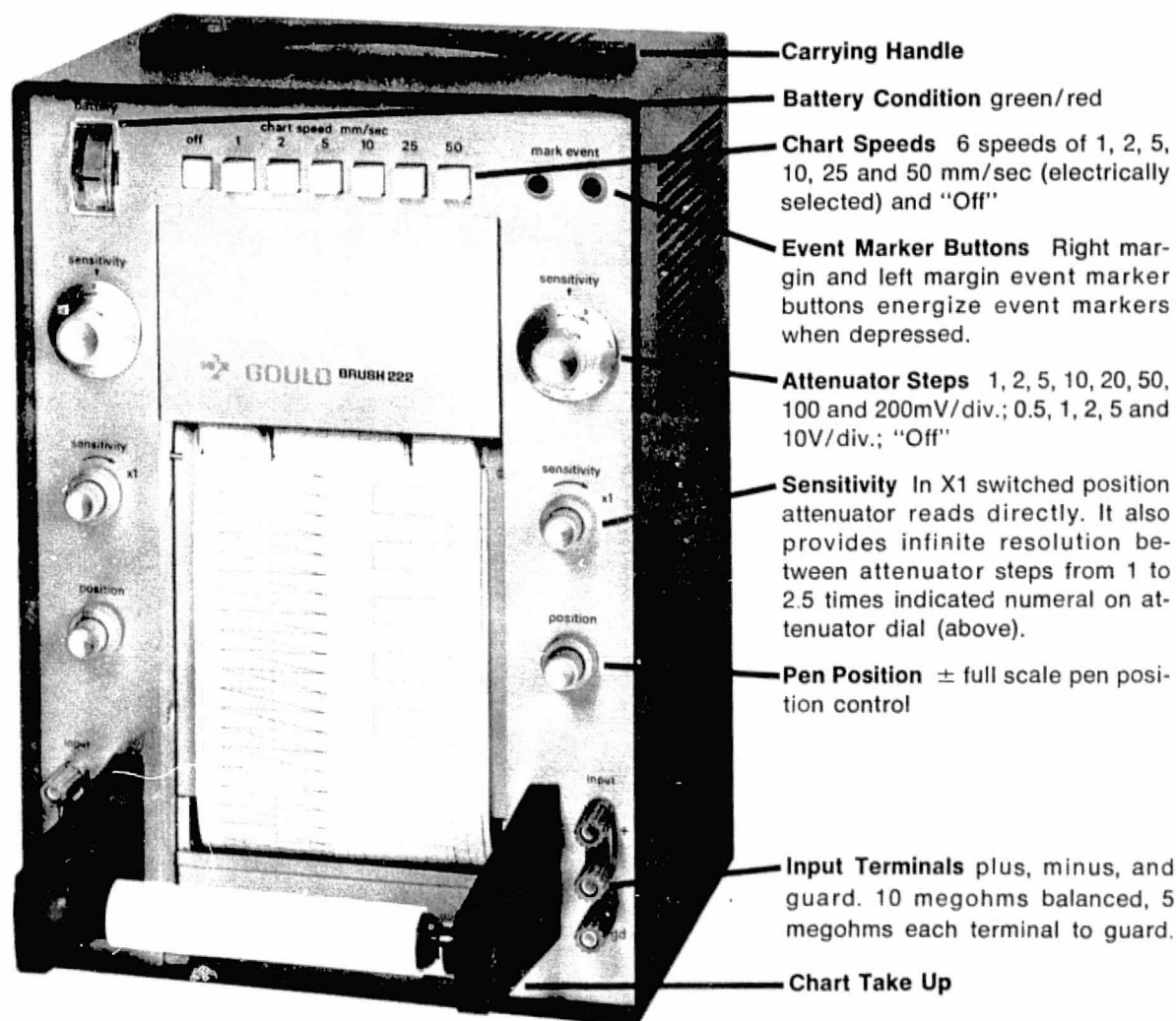
- Self-powered — 10 second warm-up
- Completely portable
- Internal charger
- Balanced, floating and guarded inputs
- Variable chart speeds
- 1 millivolt sensitivity
- 99.5% linearity, 30 Hz response full scale
- Pressurized ink writing
- Rectilinear trace presentation

The solid state Brush 222 is an internally powered, accurate, rugged, lightweight, 2 channel recorder you can use anywhere... and get crisp, clear, smudge-free records from a pressurized ink system based on

more than 100,000 channels of experience.

This completely self-contained portable recorder has two 40 mm analog channels and two event markers. Other features include built-in pre-amplifiers with electronic limiters, a measurement range from 1 millivolt/division to 500V full scale, linearity of 99.5% enforced by the exclusive Brush frictionless pen position servo system, frequency response above 30 Hz full scale, and six chart speeds. The external d-c chart drive mode permits variable chart speeds over the full range from 1 mm/sec to 50 mm/sec.

Add to this its internal battery powered operation with only 10-



Carrying Handle

Battery Condition green/red

Chart Speeds 6 speeds of 1, 2, 5, 10, 25 and 50 mm/sec (electrically selected) and "Off"

Event Marker Buttons Right margin and left margin event marker buttons energize event markers when depressed.

Attenuator Steps 1, 2, 5, 10, 20, 50, 100 and 200mV/div.; 0.5, 1, 2, 5 and 10V/div.; "Off"

Sensitivity In X1 switched position attenuator reads directly. It also provides infinite resolution between attenuator steps from 1 to 2.5 times indicated numeral on attenuator dial (above).

Pen Position  $\pm$  full scale pen position control

Input Terminals plus, minus, and guard. 10 megohms balanced, 5 megohms each terminal to guard.

Chart Take Up

## E.I. 150A RECORDER, STRIP CHART (CONT.)

seconds warm-up time and its balanced, floating and guarded inputs, and you have in the Brush 222 the most versatile 2-channel recorder available anywhere.

Since both inputs are isolated from each other, from chassis and from the output, the unit can be used with all types of signal sources — grounded, floating or driven off-ground — without affecting accuracy or creating system noise.

The internal battery supply, consisting of two sealed lead-lead dioxide Gould GELYTE® batteries, has a total operating life of up to 6,000 hours when recycled by the recorder's built-in charger. The charger is activated simply by plug-

ging its power input module into an external source of a-c or d-c (depending upon the model selected).

The batteries allow continuous operation for up to 12 hours and can be completely recharged in 16 hours — so you can use the Brush 222 all day and recharge its batteries overnight. Since they are sealed, the batteries require no maintenance... there are no fluids to add, no liquid levels to check, and no annoying leaks. To eliminate the recording of inaccurate data an automatic ink shut-off is actuated if the battery-voltage falls below a predetermined level.

"Line-assisted" operation allows unrestricted recording time. This is accomplished by powering the

charger from an external source at all times, so as to keep a full charge on the batteries.

Thanks to the Brush pressurized ink system, traces are clear, crisp, dry and smudge-free. A disposable ink cartridge holds up to a 1-year supply of ink and can be cleanly replaced in minutes. Whenever the power is off or low, or the chart paper runs out, the writing system stops and ink is withdrawn from the pen tip.

Rectilinear trace presentation, another Brush hallmark, facilitates accurate interpretation of data and waveforms produced by this recorder.



Disposable, self-pressurized ink cartridge. Provides ink supply for about 1 year of normal recording.

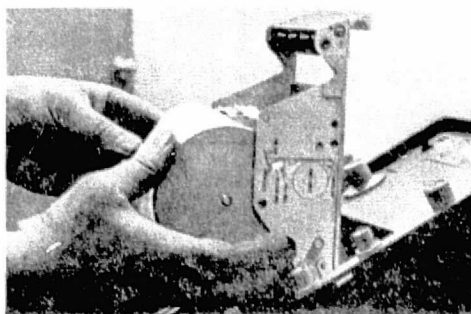
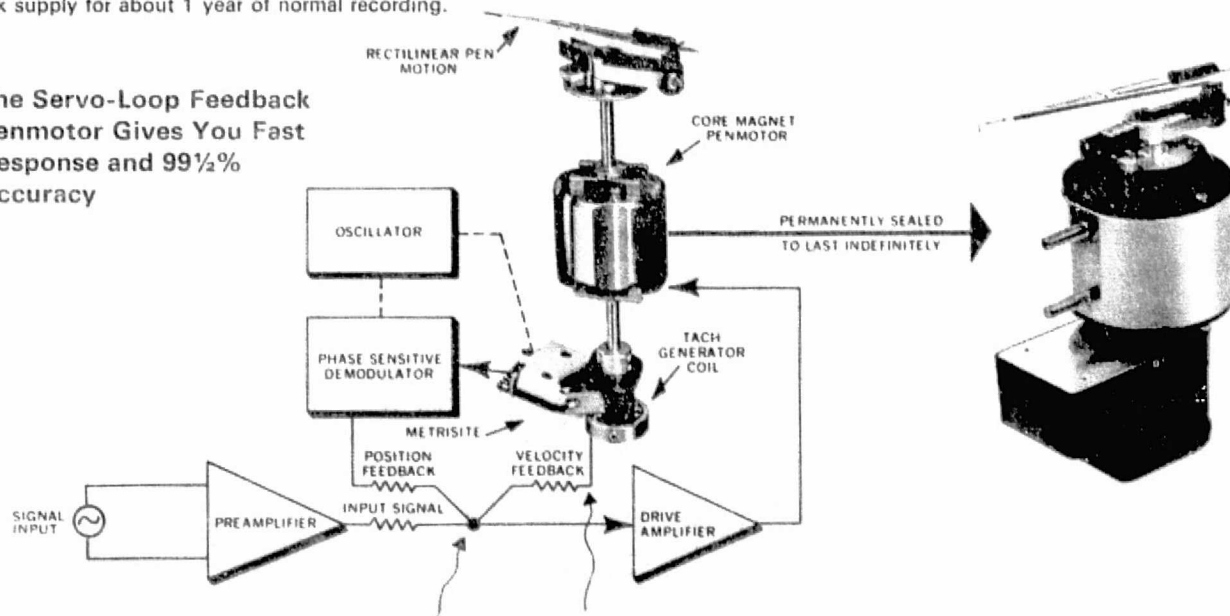


Chart paper roll can be replaced in seconds. Table snaps out and pressure on a lever opens and closes chart holder. Holds a roll 275 ft. of high contrast paper or 400 ft. of reproducible paper.

### The Servo-Loop Feedback Penmotor Gives You Fast Response and 99½% Accuracy



±d-c output of Metrisite transducer is proportional to pen-displacement from center. It is connected so that input to drive amplifier is always an "error" voltage proportional to difference between where pen is and where it ought to be.

Output of tach generator is proportional to angular velocity of pen shaft, minimizes overshoot on steep wavefronts.

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# E.I. 150A RECORDER, STRIP CHART (CONT.)

BULLETIN 442-4  
NOVEMBER, 1971

## BRUSH 222 RECORDER SPECIFICATIONS

Number of Channels	2 analog, 2 event located on left and right margins	In-Phase Rejection	80 dB at 60 Hz with 10 kilohm unbalance chassis ground to guard
Channel Span	40mm (50 divisions)	Signal Limiter	Built-in, adjustable, instant-acting electronic limiters prevent damage to analog pens from off-scale signals
Frequency Response	At 50-div: Flat within $\pm 2\%$ of full scale from d-c to 30 Hz At 10-div: Flat within $\pm 2\%$ of full scale from d-c to 70 Hz: 3 dB down @ 100 Hz	Warm-up Time	10 seconds
Non-Linearity	$\pm 0.5\%$ full scale	Zero Instability	$\pm 0.1$ div/8 hrs; $\pm 0.1$ div/ $^{\circ}\text{C}$ from 15-30 $^{\circ}\text{C}$
Noise	0.1 division at max. sensitivity and $R_s = 50\text{K ohm}$	Gain Instability	$\pm 0.1\%$ / 8 hrs; $\pm 0.05\%$ / $^{\circ}\text{C}$ from 15-30 $^{\circ}\text{C}$
Trace Presentation	Rectilinear	Chart Speeds	1, 2, 5, 10, 25, 50 mm/sec push-button selected using internal d-c chart drive External d-c chart drive, 0 to 5V d-c input provides stepless adjustment of chart speeds from 1 mm/sec to 50 mm/sec
Trace Width	0.01" nominal	Chart Speed Accuracy	$\pm 1\%$
Marking Method	Pressurized fluid	Operating Temperature	0 $^{\circ}\text{C}$ to 55 $^{\circ}\text{C}$ . Recorder within specification between 15 $^{\circ}\text{C}$ to 35 $^{\circ}\text{C}$
Marking Fluid Capacity	1 oz.-28 gm (sufficient for one year of normal recording); replaceable throw-away cartridge	Storage Temperature	-40 $^{\circ}\text{C}$ to +35 $^{\circ}\text{C}$ (batteries limiting factor)
Measurement Range	1 millivolt/chart division to 500V d-c full scale (50 chart divisions)	Power Input	Self-powered by two lead-lead dioxide 6V batteries (see Ordering Information). Battery output connector on rear of recorder.
Attenuator Steps	1, 2, 5, 10, 20, 50, 100, 200 mV/div., 0.5, 1, 2, 5, 10V/div., "OFF"	Operating Time	8-12 hrs continuous operation without line assistance, depending upon chart speed and signal frequency.
Maximum Safe Differential Input Voltage	500V d-c or peak a-c either terminal to guard or ground, or between each terminal	Recharging Time	16 hrs. max.
Maximum Common Mode Voltage	500V d-c or peak a-c at any attenuator setting between input terminals and chassis ground. 5000 x attenuator setting up to 500V between input terminals and guard.	Battery Life	150 to 500 cycles over one year period.
Input Circuit	Three terminal, Differential floating, balanced to guard. Chassis ground terminal at rear	Weight	26 lbs (11.8 kg).
Input Impedance	10 megohms balanced, 5 megohms each terminal to guard	Outline Dimensions (nominal)	9" w x 13" h x 8" d 13cm x 33cm x 20cm

## ORDERING INFORMATION

### Standard Recorders

### Model Number

All recorders include two batteries, built-in charger, and one adaptor module for charging or "line assisted operation" as listed below:

For 115 volts, 50-400 Hz, 45 VA	15-6325-00
For 230 volts, 50-400 Hz, 50 VA	15-6325-01
For 12V d-c to 33V d-c, 1 amp	15-6325-02

### Accessories

### Model Number

Starter Kit Includes 12 rolls Accuchart® paper, gram gage, 2 pen-adjust wrenches, dust cover	11-6250-00
Replacement Kit Includes 12 rolls chart paper, 2 analog pens, 2 event pens, 1 oz. ink cartridge	11-6251-00
Rack Mounting Kit	11-1202-08
Chart Takeup (External)	11-6402-03
Event Marker, Interchannel	11-6221-01
Internal One-second Timer	11-6101-41

### Additional Power Adaptor Modules

For 115 volts	782235
For 230 volts	782233
For 12V d-c to 33V d-c	782237
Cigarette Lighter Cable Assembly (negative ground)	782339

### Supplies

### Model Number

Chart Paper — Two 40mm grids — 50 divisions	
275 ft (84 meters) Hi-contrast	11-2923-31
400 ft (122 meters) Reproducible	11-2923-43
Analog Pen	11-2823-33
Event Marker Pen	11-2873-20
Ink Cartridge	11-2730-01
Battery	281296

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Gould Inc., Instrument Systems Division  
3631 Perkins Avenue, Cleveland, Ohio 44114  
Telephone (216) 361-3315



**GOULD BRUSH**

E. I. 150B RECEIVER, BIOTELEMETRY  
(E.U. 42 Vertebrate Research Support Unit.)

Purpose

To demodulate RF signals transmitted by microbackpacks or implants in vertebrates.

Requirements

Reception of signals from biotelemetry transmitters for electrocardiography (ECG), electroencephalography (EEG) and electromyography (EMG), temperature (DBT), pressure, etc.

Hardware Status

Rating: Re-design

The units could be built using available commercial components.

Technical Description

Estimated properties of a flight unit are:

Weight:	0.5 kg (1.1 lb)
Power:	10 watts
Volume:	1 dm <sup>3</sup> (0.04 ft <sup>3</sup> )

Development Time: 6 months

E.I. 153 RECORDER, VOICE  
(E.U. 2 Data Management Unit.)

Purpose

A portable recorder for voice recording of experiment results and observations, as well as comments from human test subjects during or following subjective experiments involving man.

Requirements

No special requirements are foreseen. A portable cassette tape recorder with automatic recording volume level control would be suitable. Maximum recording time required is estimated at 30 minutes per day.

Hardware Status

Rating: Re-Package

Commercial units should be usable in spaceflight with minor modifications. For short missions, battery recharging would probably not be necessary. If it were, the charger would probably have to be altered to use 28 volt d.c. power, a minor change. A Craig Corp. Model 2605 has been rated by the F.A.A. as acceptable for use in commercial aircraft. This model was used as the basis for the properties assumed below.

Technical Description

The Craig Corp. Model 2605 has the following properties:

Weight	0.77 kg (1.7 lb)
Size	8.9 cm wide $\times$ 14.0 cm high $\times$ 3.5 cm deep (3.5 $\times$ 5.5 $\times$ 1.4 inches)
Volume	0.44 dm <sup>3</sup> (0.015 ft <sup>3</sup> )
Voltage	4.5 volts d.c. (batteries)
Nominal operating time on one battery charge: 5 hrs	
Charging time	14 hrs

Cassettes for this type of recorder typically have the following properties:

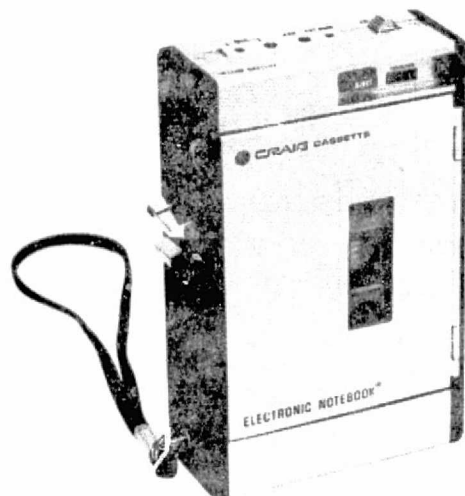
Weight	45 g (0.1 lb)
Envelope	10 $\times$ 6.6 $\times$ 1.2 cm (4 $\times$ 2.5 $\times$ 0.5 inches)
Volume	0.08 dm <sup>3</sup> (0.003 ft <sup>3</sup> )
Total recording time: 120 minutes	

E.1. 153 RECORDER, VOICE (Continued)

To account for cassettes and other equipment such as charger, cards, microphone, etc., the following weight and volume was assumed for dedicated laboratories of 7 days duration.

Total weight allowance	1 kg (2.2 lb)
Total envelope volume	1 dm <sup>3</sup> (0.035 ft <sup>3</sup> )

Development Time: 4 months

**CRAIG®****2605**

### MINIATURE PORTABLE CASSETTE RECORDER

- "ELECTRONIC NOTEBOOK"™ FOR POCKET OR BRIEFCASE
- INSTANT-RESET DIGITAL COUNTER
- BUILT-IN CONDENSER MICROPHONE AND SPEAKER
- LOW-BATTERY WARNING LAMP
- LEATHER-TEXTURED VINYL CASE, AND HAND-STRAP
- POWERED BY STANDARD PENLIGHT BATTERIES, OR OPTIONAL RECHARGE KIT
- PAUSE BUTTON

The CRAIG 2605 is a pocket-size, precision "Electronic Notebook"™ with a self-contained microphone and speaker that plays standard size cassette tapes. It weighs slightly more than a pound and is so small it can be tucked in briefcase, pocket or purse, or casually carried by its handstrap. It operates by fingertip controls; has built-in digital counter and low-battery warning light. By using the earphone, you can play the CRAIG 2605 in plane, waiting room, office, school or anywhere without others hearing. And for saving sounds, you can't find another recorder as convenient as the CRAIG 2605 Miniature.

### TECHNICAL DATA

<b>Reel Size:</b>	Standard Compact Cassette
<b>Recording Time:</b>	60 min. total with C-60, more with extended-play Cassette
<b>Rewind Time:</b>	180 sec. (C-60) cassette)
<b>Tape Speed:</b>	1 7/8 ips
<b>Wow and Flutter:</b>	Less than 0.6% rms
<b>Output Power:</b>	400 Milliwatts peak
<b>Signal/Noise Ratio:</b>	Better than 35 dB
<b>Frequency Response:</b>	200-6000Hz
<b>Transistors:</b>	12
<b>Record System:</b>	Half-track, AC Bias, auto-level control
<b>Erase System:</b>	DC
<b>Inputs:</b>	Microphone, 10 K ohms, -70 dBm
<b>Outputs:</b>	Earphone/Ext. Speaker, 8 ohms
<b>Speaker Size:</b>	2.4 inch
<b>Microphones:</b>	Built-in plus external dynamic, 500 ohms, with remote control switch
<b>Power Source:</b>	3-"AA" size batteries, or optional rechargeable kit
<b>Size:</b>	3 1/2" W x 5 1/2" H x 1 3/4" D
<b>Weight:</b>	1.7 lbs. (incl. batteries)
<b>Accessories Supplied:</b>	External Remote Control Microphone, Earphone, Case, Handstrap
<b>Accessories Available:</b>	9215 AC Charger/ Battery Kit 9501 Telephone Pickup 9303 Footswitch 9602 Radio Recording Cord 9603 Auxiliary Recording Cord 8211 C-30 Cassette 8212 C-60 Cassette 8213 C-90 Cassette 8214 C-120 Cassette
<b>Guarantee:</b>	Standard 90-day warranty

Description and data subject to change without notice.

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E.I. 153A ROTATING LITTER CHAIR AND CONSOLE  
(E.U. 12 - Biomedical/Behavioral Research Support Unit)

Purpose

For rotation of human test subjects in order to perform various tests of vestibular function.

Requirements

The rotating litter chair (RLC) will be very similar to that flown aboard Skylab. Thus, for detailed requirements, references should be made to Skylab documents, such as the reference cited below. The RLC was used in Skylab experiment M131, Human Vestibular Function. The general requirements of the RLC are:

1. An articulated chair structure to provide upright seating, a supine position, and intermediate positions and adjustments.
2. Capable of programmed rotational acceleration/deceleration profiles, as well as constant angular velocities.
3. An angular velocity range of 0-188 rad/min. (0-30 rpm). (This range may be increased for future flights.)
4. The chair rotates the subject about an axis which passes through the center of gravity of the subject and which is perpendicular to a plane passing through the lateral canals.

Hardware Status

Rating: Space Qualified.

The Skylab Rotating Litter Chair design should be usable with minor modifications.

Technical Description

The Skylab chair was used as a basis for the data presented herein, which was taken from the reference cited below

The RLC is an electric motor driven, servo controlled, precision rotating chair, which can tilt in the pitch and roll axes while in the static mode. The chair is constructed of aluminum tube framing and has a fabric-covered expanded metal seat and back. The chair can be converted to a litter mode and its seating attitude can be

pitched forward or backward in a compound plane. Rotation occurs only in an up-right position. The chair contains proximity sensors for detecting and signaling subject head position.

The drive motor is a servo controlled, d.c. brush type and is equipped with a nitrogen blanket for protection of the motor brushes from the oxygen in the cabin atmosphere. To eliminate uncontrolled stimulation and allow sensitive functional measurements of the vestibular organs, rotation is accomplished by direct motor coupling with no gear slack and little vibration.

The control console contains a tachometer display, a direction reversing switch, a mode selector switch, a speed and acceleration program selector, oculogyral illusion (OGI) and motion sensitivity data entry buttons, timing and programming circuits, and a cadence device selector and speaker, see attached figure.

The properties of the rotating litter chair and control console are described below.

Weight:

RLC	69.7 kg (153.6 lb)
Control Console	30.5 kg ( 67.3 lb)
Total	100.2 kg (220.9 lb)

Dimensions (see Figures):

RLC, stowed	30.5 cm W × 68.6 cm H × 81.3 cm D (12" W × 27" H × 32" D)
Control Console	30.5 cm W × 55.9 cm H × 40.6 cm D (12" W × 22" H × 16" D)

Envelope Volume:

RLC, stowed	170 dm <sup>3</sup> (6 ft <sup>3</sup> )
Control Console	69 dm <sup>3</sup> (2.4 ft <sup>3</sup> )

Power:

127 watts (max.), 28 volt d.c.  
Range, 60 to 127 watts  
Average, 85 watts (estimated)  
Duty cycle, 1.5 minutes during each procedure

Heat Rejection:

TBD. Will depend upon usage rate. Heat is rejected to cabin air.

Data Management:

Analog and discrete measurements as listed in the cited reference are presented below. Controls and displays are handled by the control console.

## M131 Analog Measurements

<u>Parameter</u>	<u>Quantity</u>	<u>Measurement Range</u>	<u>Resolution (±% F.S.)</u>	<u>Accuracy* (±% F.S.)</u>
Current, RLC Motor	1	0 to 12 A	**	5
Speed, RLC Motor	1	0 to 32 rpm	**	1***
Voltage, Converters (1 plus/1 minus)	2	0 to 28 Vdc	**	1

\*Measurement accuracies do not include the decoder, telemetry, and ground data handling errors.

\*\*Resolution is limited to the telemetry system output, a 256-count binary signal. One count is 1/256 of full scale.

\*\*\*This is 1% of the indicated value, not full scale.

## Discrete/Event Measurements

<u>Parameter</u>	<u>Quantity</u>	<u>Threshold of Activation</u>	<u>Accuracy</u>
Motion and Sensitivity Response Matrix	15	N/A	N/A
Rpm Range 1, 2, 3	3	↓	↓
OGI Acceleration Period	1		
OGI Deceleration Period	1		
MS Cadence Signal Period	1		
Head Motion Acknowledgement, Left	1		
Head Motion Acknowledgement, Right	1		
Head Motion Acknowledgement, Front	1		
Head Motion Acknowledgement, Back	1		
Direction of Rotation	1		
Experiment State OGI/MS	1		

## Interfaces:

EPS & CDMS. Hardline between RLC and Control Console. Dry nitrogen leakage to the cabin at 0.2 scc/min. (maximum).

## E.I. 153A (Cont'd)

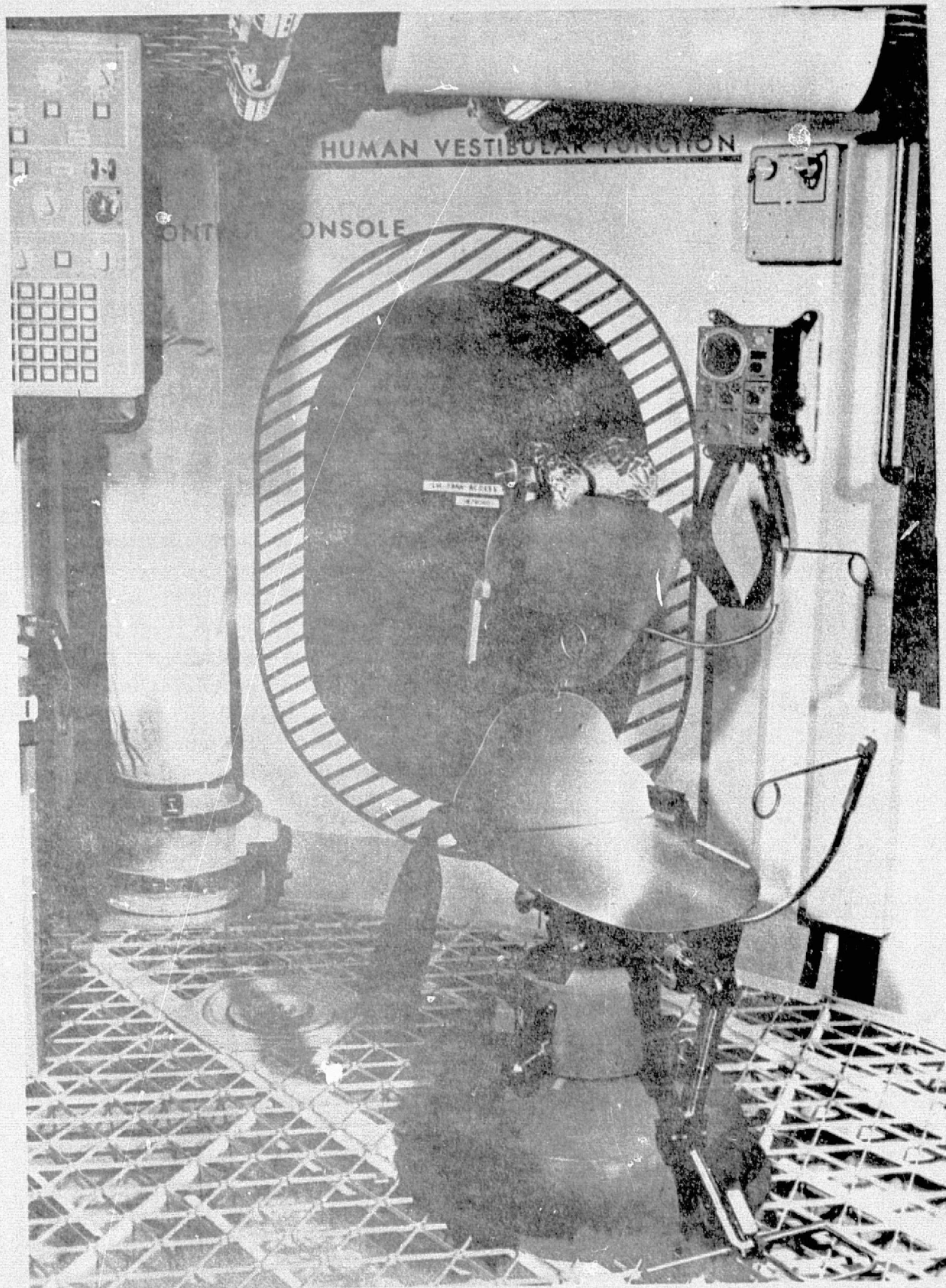
### Operations:

1. The RLC drive motor is blanketed with dry nitrogen at 5 to 20 cm water gage pressure. This serves to isolate the motor brushes from the cabin atmosphere. The nitrogen is supplied from a 1,230 cc (75 in<sup>3</sup>) bottle with a nominal operating pressure of  $10 \pm .34$  mN/m<sup>2</sup> gage (1450  $\pm$  50 psig). The bottle proof pressure is 34.5 mN/m<sup>2</sup> gage (5000 psig), and its operating temperature range is 228 to 344°K (-50 to 160°F). It is currently contained within the base of the RLC.
2. Tests with the RLC must be performed during periods of relative silence.
3. When performing oculogyral illusion and spacial localization tests, the Shuttle Orbiter angular acceleration rates will be limited depending upon the location and orientation of the RLC within the Spacelab. In Skylab, these limitations were 0.001 deg/sec<sup>2</sup> along the longitudinal axis of the Orbital Work Shop (parallel to the axis of rotation of the RLC), and 0.002 deg/sec<sup>2</sup> along the transverse axes. The linear acceleration must not exceed 0.0284 mm/sec<sup>2</sup> ( $9.33 \times 10^{-5}$  ft/sec<sup>2</sup>) along any axis.

Development Time: 12 months

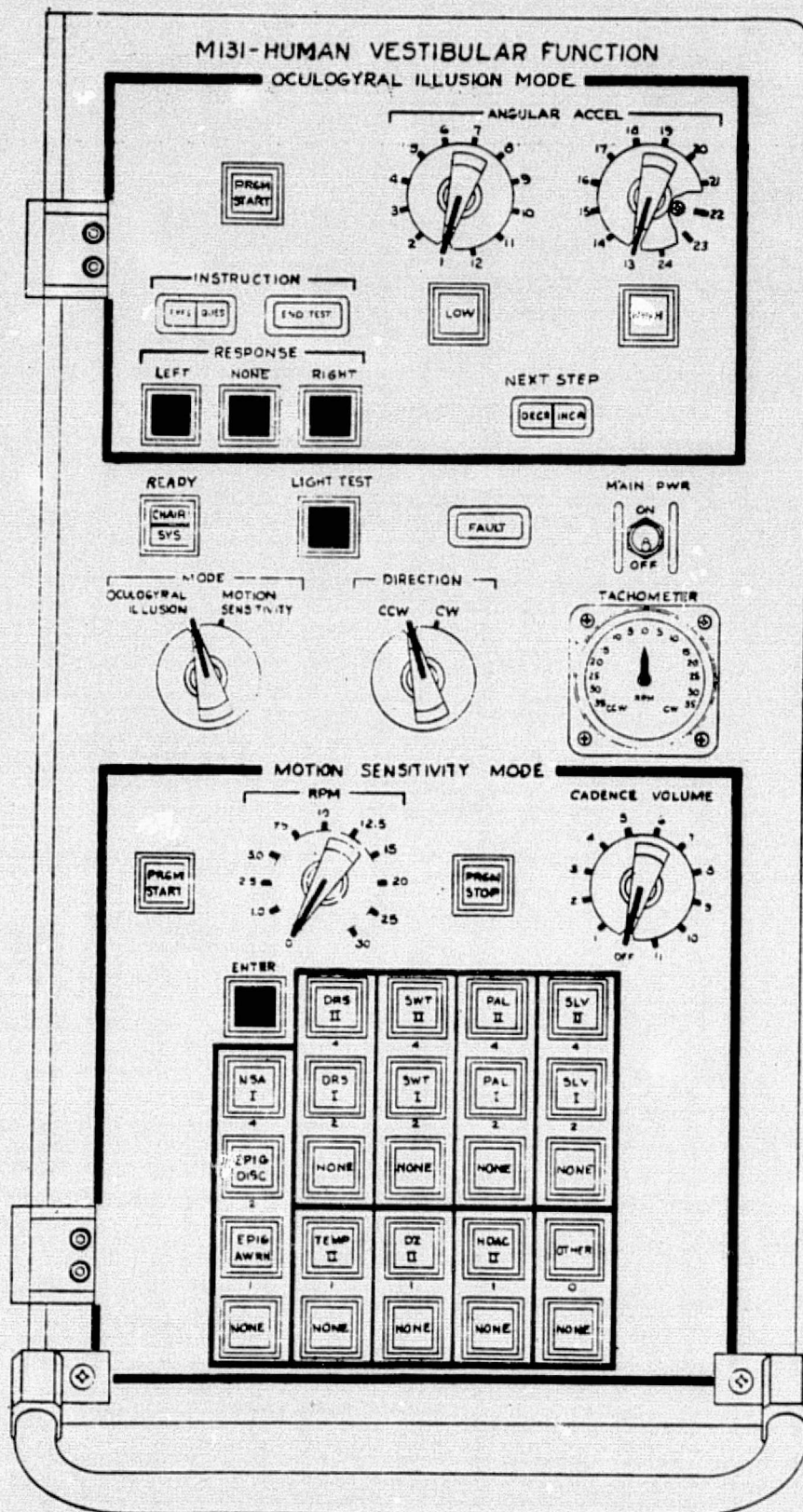
### Reference

Skylab Program OPERATIONAL DATA BOOK, VOL. I, Part One, Revision A, Report No. MSC-01549 (Vol. I) Rev. A, NASA, Manned Spacecraft Center, Houston, Tex., October 1972.



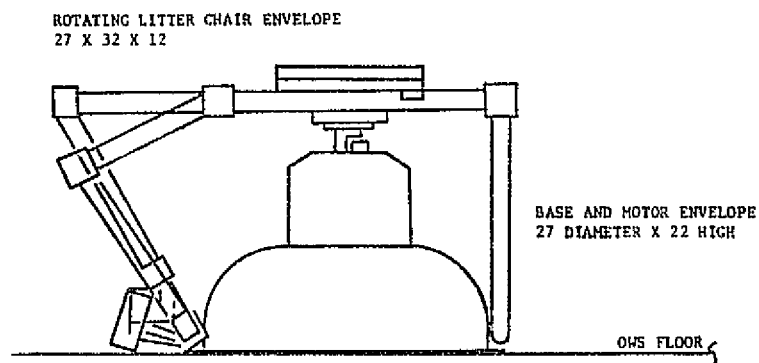
Rotating Litter Chair  
2-234

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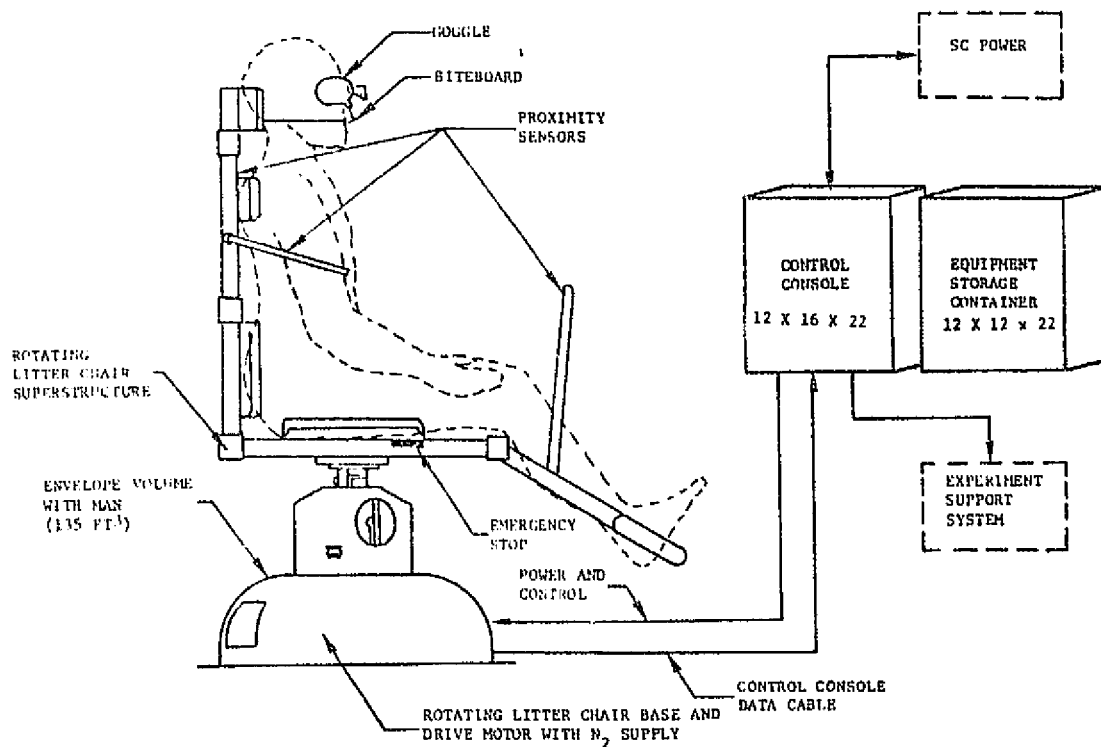


Experiment M131 Control Console

ALL DIMENSIONS IN INCHES



Experiment M131 Stowed Equipment Configuration



M131 Operating Configuration

E.I. 156 SIGNAL CONDITIONERS, (COUPLERS)  
(E. U. 2 - Data Management Unit)

Purpose

To provide electrical signal transformation between miscellaneous sensors, and the data management equipment accepting the data output from these devices.

Requirements

Requirements will vary depending upon the type of sensor, transducer, or control device being used. Conditioning may be required to supply regulated voltages to some sensors such as those using voltage dividers or isolation amplifiers.

Hardware Status

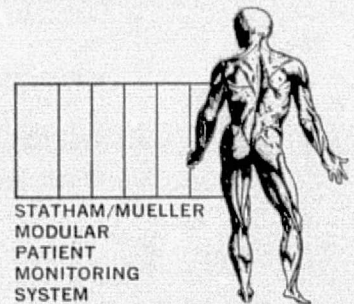
Rating: Modification

Equipment similar to that used in the Statham Mueller patient monitoring system is typical of unminiaturized couplers. Some of this commercially available equipment is described in the attached catalog sheets.

Technical Description

	<u>Mueller Units</u>		<u>Preliminary Estimates, Flight Units</u>
Size	17.8 cm H x 5.1 cm W x 25.4 cm D (7" x 2" x 10")	Volume	0.5 dm <sup>3</sup> (0.02 ft <sup>3</sup> )
Volume	2.31 dm <sup>3</sup> (0.082 ft <sup>3</sup> )	Power	2 watts
Power	About 10 watts	Weight	0.2 kg (0.44 lb)
Weight	0.5 to 2 kg (1.1 to 4.4 lb)		

Development Time: 6 months



## Venous Pressure Module, Model SM1011

The SM1011 Venous Pressure Module accepts venous pressure analog from either the SM1007 Blood Pressure Amplifier, or the SM1008 Bridge Amplifier, and from the input data computes and displays mean venous pressure.

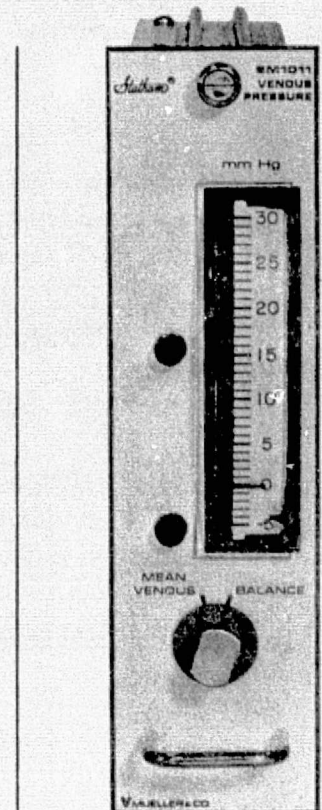
A display meter on the front panel of the module indicates mean pressure over a range of  $-5$  to  $+30$  mm Hg. Two adjustable pointers on the face of the meter permit the physician to select acceptable minimum-maximum pressure limits. Should mean venous pressure exceed either of these limits, an alarm signal is generated by the SM1011 Module, triggering an audio/visual alarm at the central monitoring station. Minimum-pressure alarm function is feasible because the SM1011 removes the respiration component, largely responsible for negative venous blood pressure readings.

The Venous Pressure Module, Model SM1011, provides a standardized signal for display, strip-chart recording, magnetic tape recording, and/or computer analysis of the pressure reading.

### Specifications

Dimensions	Standard SM Series 2-in Module
Meter scale	$-5$ - $+30$ mm Hg
Non-linearity	$\pm 1.0\%$ FS from best straight line at constant line voltage and ambient temperature
Stability	$\pm 2.0\%$ FS over temperature range of $50$ - $140^\circ\text{F}$ , and line voltage variations of $95$ - $130\text{V}$ input to SM1014 or SM1034 Power Supply Modules
Output ripple	Negligible at full scale, $1.0\%$ peak-to-peak at $10$ breaths/min, and $50\%$ modulation
Input impedance	$100\text{ k}\Omega$ minimum
Front-panel controls	Two-position selector switch/Mean venous/Balance NOTE: When set on "BAL," the selector switch also provides a balance indicator for the SM1007 or SM1008 Module, for purposes of setting atmospheric reference pressure.

We strive constantly for product perfection, both in design and construction. As a consequence, detailed specifications are subject to change without notice.



### Features

- Minimum-maximum pressure limits adjustable on meter face
- Alarm signal generated when either pressure limit is exceeded
- Standardized signal for display, strip-chart or magnetic tape recording, computer analysis
- Fits any free position in an SM Series Cabinet

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## Bridge Amplifier Module, Model SM1008

The SM1008 Bridge Amplifier module provides excitation voltage for strain gage devices such as blood pressure transducers, and amplifies the signals received from them, conditioning the signals for oscilloscope display, strip-chart recording, magnetic tape recording, and/or computerization. It has 6 sensitivity ranges: 0 to 1 millivolt, 0 to 2 millivolt, 0 to 5 millivolt, 0 to 10 millivolt, 0 to 20 millivolt, and 0 to 50 millivolt, all selected by a 6-position switch; and a fine adjustment set by a vernier control that allows continuous gain over the range from 1 to 125 mV. Frequency response is selected by a 3-position bandwidth switch: dc to 0.16 Hz, dc to 20 Hz, and dc to 100 Hz.

Amplifier SM1008 is used with non-standardized 4-leg Wheatstone bridge transducers for a variety of physiological measurements. Among the transducers with which it is used are Statham's blood pressure transducers P23AA, P23BB, P23De, P23Gb, P23H, SF1, and SF4. It is also used with Statham's universal transducing cells UC2, UC3, and UC4, which, with appropriate accessories, are suitable for such measurements as force, displacement, weight, TKD, apex cardiograph, muscle strength, and blood pressure.

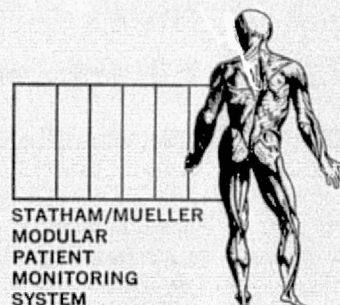
In common with the other elements of the system, an outstanding level of performance is achieved without demanding the operator's constant attention, thus allowing concentration on the information that is being made available. The controls on the front panel are: a selector switch for frequency, selector switch for sensitivity, vernier gain control, a knob to adjust the balance and a calibrator pushbutton.

In keeping with the system's design, output is standardized. This offers several significant advantages to the user: greater flexibility; insurance against obsolescence; compatibility with computers and recorders; ease of installation and service; and initial cost is kept down.

### Specifications

Signal input:	
Source	4-leg Wheatstone bridge transducers
Excitation voltage	7.5 V dc, $\pm 5\%$
Transducer resistance	200 to 800 $\Omega$
Sensitivity: 6 calibrated positions	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">           0 to 1 mV full scale            0 to 2 mV full scale            0 to 5 mV full scale            0 to 10 mV full scale            0 to 20 mV full scale            0 to 50 mV full scale         </div> <div>           } with 7.500 V                excitation         </div> </div>
Vernier	Allows continuous gain from 1 to 125 mV full scale
Sensitivity stability	$\pm 1.5\%$ of full scale, over specified environment
Sensitivity accuracy, including excitation and gain	$\pm 2\%$ of full scale, 1 and 2 mV ranges $\pm 1\%$ of full scale, all other ranges
Frequency response:	dc to 0.16 Hz, $-3$ dB at 0.16 Hz dc to 20 Hz, $-3$ dB at 20 Hz dc to 100 Hz, $-3$ dB at 100 Hz
Common mode rejection, 5 Vpp at 60 Hz	Better than $-80$ dB
Non-linearity	$\pm 1\%$ of full scale
Zero drift, excluding transducer	$\pm 2\%$ of full scale, from 65 to 85°F
Noise	1% of full scale, peak to peak, referred to input
Balance control	Ten-turn potentiometer with locking device
Calibration	100 k $\Omega$ $\pm 1\%$ , connected in parallel with legs 1 and 2 of Wheatstone bridge by means of pushbutton
Ambient temperature	60 to 100°F
Power	Derived from SM1014 Power Supply
Front-panel width	2" nominal
Weight	Approximately 3 pounds 9 ounces
Mounting	Position 1-7 in SM1015 Cabinet

We strive constantly to improve the quality of all our products, both in their design and in their construction. Accordingly, detailed specifications are subject to change without prior notice.



STATHAM/MUELLER  
MODULAR  
PATIENT  
MONITORING  
SYSTEM



### Features

- For blood pressure transducers and other strain gage devices
- For use with non-standardized transducers
- Sensitivity range 1 to 125 millivolts
- 3 frequency response settings
- Outstanding performance without constant attention
- Standardized-level output
- All solid-state circuitry
- Triple isolation for safety

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## Electronic Thermometer Module, Model SM1006

The SM1006 Electronic Thermometer Module accepts signals only from Satham's patient temperature probes (Rectal/Esophageal Probe SM3605 and Skin Temperature Probe SM 3604) and conditions them to provide continuous meter readout in degrees Fahrenheit and degrees Celsius. It gives warning when a pre-selected maximum or minimum limit is exceeded. It also provides a signal for audio/visual alarm at the central monitor station and a standardized signal for display, strip-chart recording, magnetic tape recording, and/or computerization.

Temperature within the pre-selected limits is indicated by a green light. A red light indicates that either the maximum or the minimum has been exceeded. The limits are set by two pointers on the large, easy-to-read meter. They may be reset at any time, within the meter range of 93 to 107° F, or 34 to 41° C.

Satham's Rectal/Esophageal Temperature Probe, SM3605, and Skin Temperature Probe, SM3604, are standardized to  $\pm 0.2^\circ$  F; no further standardization is needed to use either of the probes with the SM1006 Electronic Thermometer. A pushbutton on the front panel provides a calibration check at the 100° F point and an indication of the meter at 100° F (half-scale point). A screwdriver adjustment on the front panel is used to correct the calibration, if needed.

In common with the other elements of the system, an outstanding level of performance is achieved without demanding the operator's constant attention, thus allowing concentration on the information that is being made available. The only control on the front panel is the pushbutton to check calibration.

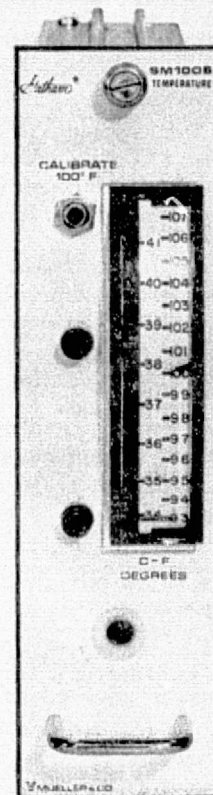
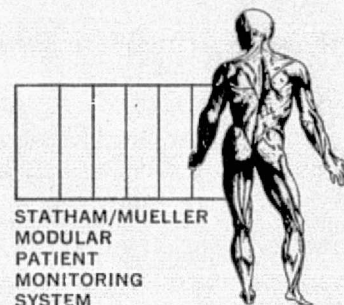
In keeping with the design of the system, output is standardized. This offers several significant advantages to the user: greater flexibility — insurance against obsolescence — compatibility with computers and recorders — ease of installation and servicing — initial cost can be kept down.

As is true for all elements of the system, all solid-state circuitry is employed, and is rated conservatively throughout. Careful attention is paid to every design detail; full advantage is taken of modern electronic and semiconductor technology. Thus, with Satham's tradition of using the finest materials, the most careful manufacturing, and the most rigid quality control, high reliability and long trouble-free life are assured, with resultant long-range economy.

### Specifications

Meter Scales	93 to 107°F 34 to 41°C
Non-Linearity	$\pm 1\%$ of full scale
Accuracy	$\pm 0.4^\circ$ F, using Satham Probes SM3604 or SM3605
Calibration	At 100°F by front-panel pushbutton
Calibration Adjustment	Single-turn potentiometer, screwdriver adjustable
Ambient Temperature	60 to 100°F
Power	Derived from SM1014 Power Supply
Front-panel Width	2", nominal
Weight	Approximately 3½ lbs.

We strive constantly to improve the quality of all our products, both in their design and in their construction. Accordingly, detailed specifications are subject to change without prior notice.



### Features

- Rectal, esophageal, or skin temperature
- Continuous meter readout in °F and °C
- Maximum/minimum alarm
- Standardized probes
- Pushbutton calibration check
- Outstanding performance without constant attention
- Standardized-level output
- All solid-state circuitry

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E.I. 156F SONOCARDIOGRAM  
(E.U. 31 - Biomedical Research Support Unit)

Purpose

To measure human or primate heart dimensions.

Requirements - TBD.

Hardware Status

Rating: Redesign

Prototype unit has been built and tested at NASA/ARC. (Contacts: Bob Lee, 415/965-5473, and Henry Lum, 415/965-6530.)

Technical Description

The device can be used to determine the two-dimensional outline of the heart and also to measure the vertical distance between the sensor matrix and the heart. It can thus give a dynamic three-dimensional picture of the side of the heart being observed. Single vertical (or depth) measurements can also be used as a measure of the stroke volume of the heart. The device produces an image about 40 times per second.

The NASA/ARC sono-cardiogram display unit is built around a modified Hewlett Packard Model 1700 oscilloscope. Two-dimensional heart diagrams or vertical depth dimensions are displayed on the CRT. The unit uses 20 "D" size NiCd batteries for power, in order to avoid the introduction of RF noise into the spacecraft electrical systems.

The current sono-cardiogram equipment requires the use of an auxiliary data processing unit called a digital video compression unit. This unit processes the sono-cardiogram signal for entry into the CDMS and transmission to ground. The properties of the video unit are dependent upon the resolution required. The test unit at NASA/ARC had a resolution of about 200 lines and this unit was used as the basis of the properties listed below.

E.I. 156F SONOCARDIOGRAM (Cont'd)

Weight:

Sensor & Display Unit	15.4 kg (34 lb)
Video Unit	3.6 kg (8 lb)
Total	19.0 kg (41.9 lb)

Dimensions:

Sensor & Display Unit	35.6 × 22.9 × 61 cm (14 × 9 × 24 inches)
Video Unit	31 cm W × 15 cm H × 20 cm D (12" × 6" × 8")

Total Volume:

Sensor & Display Unit	49.7 dm <sup>3</sup> (1.76 ft <sup>3</sup> )
Video Unit	9.3 dm <sup>3</sup> (0.33 ft <sup>3</sup> )
Total Volume	59 dm <sup>3</sup> (2.08 ft <sup>3</sup> )

Power:

Sensor & Display Unit	20 watts (estimated, battery powered)
Video Unit	12 watts
Total	32 watts

Heat Rejection: 32 watts to air

Data Management: The digital video compression unit produces 2 mbit/sec while the sono-cardiogram is in use.

Location: No constraints on location.

Interfaces: CDMS hardline to high rate recorder or telemetry.

Development Time: 12 months

## E.I. 157 SOUND LEVEL METER

(E. U. 5 - Biochemical & Biophysical Analysis Unit)

### Purpose

To be used for sound level surveys and limited frequency analysis. The instrument will also function as a monitor for certain biological experiments.

### Requirements

Frequency response:	125-8K Hz (est.)
Sound level range:	40-100 db (est.)

### Hardware Status

Rating: Repackage.

Commercial hardware should be usable.

### Technical Description

Preliminary properties were based on a Bruel and Kjaer Instruments, Inc., Model 3501/S Portable Sound and Vibration Instrumentation System. It consists of a Model 2203 Sound Level Meter, Model 1613 Octave Band Filter, and Model 4220 Piston phone Calibrator. Accessory equipment includes various microphones, cables, etc.

System weight:	13.6 kg (30 lbs)
Envelope dimensions (carrying case)	43.2 cm H x 50.8 cm W x 15.2 cm D (17" high, 20" wide, 6" deep)
Envelope volume	33.4 dm <sup>3</sup> (1.2 ft <sup>3</sup> )

Development Time: 6 months

E.I. 159 STAINING SYSTEM  
(E.U. 4 - Preparation & Preservation Unit)

Purpose

To stain bacteria and blood smears for microscopic examination.

Requirements

Requires null gravity Gram & Wright staining of specimens on microscope slides. The number of staining operations will be specific to individual missions.

Hardware Status

Rating: Modification

A Slide Stainer System was developed by Beckman, Advanced Technology Operations, for NASA/JSC, and flown aboard Skylab. This unit should be usable for the life sciences laboratory. However, it may have to be refilled with reagents and water during the missions in order to provide for more than the 24 staining operations it is currently design for. Extra waste fluid storage bags will also be required. The Beckman unit is described below.

Technical Description

The Beckman/NASA Slide Stainer permits Gram staining of bacteriological material and Wright staining of peripheral blood smears. With one filling of reagents, the unit is capable of 16 Gram stains and 8 Wright stains. The system employs standard Gram stain reagents and a modified one reagent Wright stain. The stains are contained in syringe type dispensers equipped with screw adapted plungers. The reagents are routed to an enclosed staining compartment through a multiposition rotary valve. Provision is also made for air and water flushing of the staining chamber and reagent lines. A water reservoir is self-contained. Waste fluids are entrapped in a disposable bag which contains an absorbent material. The reservoir may be refilled as necessary from the spacecraft potable water supply.

Estimated properties of the staining system for the life sciences laboratory are based upon the Beckman/NASA Slide Stainer.

E.I. 159 (Cont'd)

Weight:

For 30 Days:

Stainer	2.16 kg (4.76 lb) (includes consumables for 24 stains)
---------	--

Extra consumables

for 30 Days	2 kg (estimate)
-------------	-----------------

Total for 30 Days	4.16 kg (9.17 lb)
-------------------	-------------------

For 7 Days:

Stainer	2.16 kg (4.76 lb) (includes consumables for 24 stains assumed adequate for 7-day mission)
---------	---

Dimensions:

Stainer	23.4 cm W × 10.9 cm H × 13.5 cm D (9.2" W × 4.3" H × 5.3" D)
---------	---

Envelope Volume:

Stainer	3.5 dm <sup>3</sup> (0.12 ft <sup>3</sup> ), for 7- and 30-days
---------	---

Extra consumables	4 dm <sup>3</sup> (0.14 ft <sup>3</sup> ) for 30-days only
-------------------	--

Power & Heat Rejection:	0
-------------------------	---

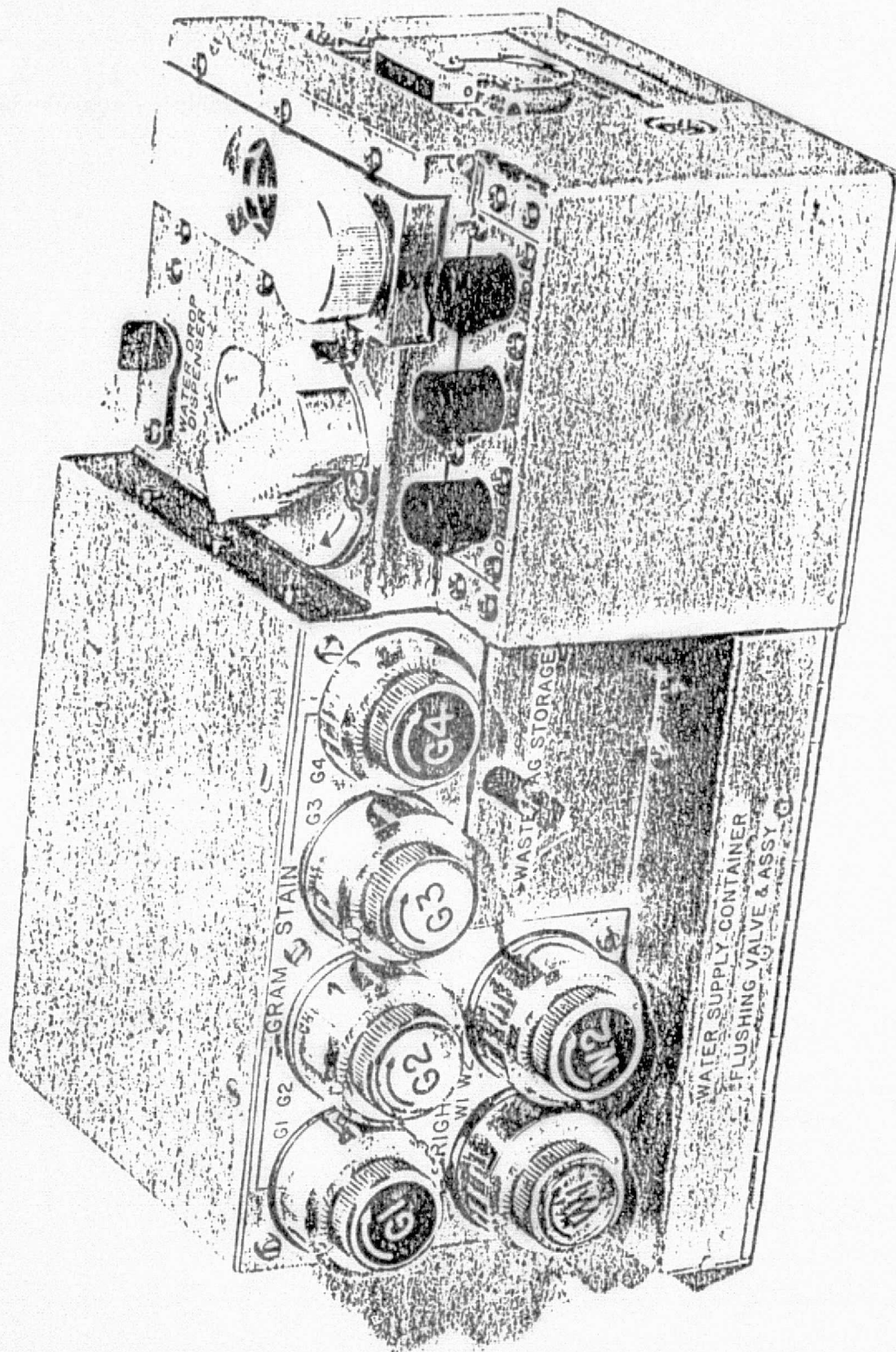
Data Management:	None
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Location:	Can be stored and deployed on a bench for use.
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Interfaces:	Water supply container should be fillable from Liquid Storage and Dispensing System (E.I. 114G, E.U. 3). Liquid waste bags should be storable in the Spacelab trash disposal bags.
-------------	--

Operations:	Liquid filling and emptying operations may be required.
-------------	---

Development Time: 6 months



Beckman/NASA Slide Stainer System

E.I. 162 STERILIZER, AUTOCLAVE  
(E.U. 6 - Maintenance, Repair & Fabrication Unit)

Purpose

To sterilize tools, containers, and other equipment for both storage and re-use aboard the life sciences laboratory.

Requirements

Specific requirements have not been determined. Autoclaves generally operate at about 400°K (127°C or 260°F) and 143 kN/m<sup>2</sup> (20.7 psig) for 20 to 30 minutes.

Hardware Status

Rating: New development.

A major problem with autoclaves in 0-g is the handling of the water and steam. The water must be maintained in contact with the heating surface by some means, and the vapor must be vented to the autoclave sterilizing section without liquid entrainment and carry-over. Many schemes for handling gas/liquid mixtures have been studied in the past and could be utilized in conjunction with the autoclave. However, the autoclave will require a full design and development program. It is doubtful whether commercially available devices could be utilized without such extensive modifications that specially built equipment would be preferable. Data on two commercially available autoclaves is contained below for comparison purposes.

Technical Description

A small, commercially available autoclave (Speedclave Model 7) is made by Ritter Co., Rochester, NY. It is gravity-dependent and is included herein for comparison only. Its properties are:

Weight:	13.6 kg (30 lb) empty (Water is approx. 1.5 kg)
Outside Dimensions:	39.4 × 34.6 × 31.1 cm (15-1/2 × 13-5/8 × 12-1/4 inches)
Internal Dimensions:	36.8 cm long × 19.1 cm dia. (14-1/2" × 7-1/2" dia.)
Outside Volume:	42.4 dm <sup>3</sup> (1.5 ft <sup>3</sup> )
Power:	1000 watts (est.), 115 volt, 60 Hz, 10 amp. max.

## E.I. 162 STERILIZER, AUTOCLAVE (Cont'd)

Another commercially available autoclave (see attached catalog sheet) is similar in design to a pressure cooker. It was used as the basis of the rotating autoclave concept discussed below.

A simple rotating autoclave which might be suitable for zero-g use is shown in the attached sketch. It is essentially an insulated pressure cooker with thermostatically controlled heating coils in its cylindrical walls. Rotation of the device would force the water against the walls and maintain contact with the heated surface. The center section would contain only vapor and would be the location for the air vent. Water could be metered into the loaded and sealed autoclave by a syringe type of device. The autoclave could be used for dry sterilization as well as steam sterilization, provided that the proper temperature controls were included. Following the autoclaving process, the steam could be vented overboard or a dry gas could be used to purge the steam and carry it to the cabin ECS condenser.

Estimated properties for a spacecraft autoclave are:

Weight:	
Fixed	10 kg (22 lb)
Consumable	1 kg (distilled water @ 0.05 kg per load)
Total	11 kg (for 7 or 30 days)
Dimensions (Envelope):	33 cm dia. × 40.6 cm high (13" dia. × 16" high)
Volume (Envelope)	34.7 dm <sup>3</sup> (1.23 ft <sup>3</sup> )
Power:	300 watts, 28 volt d.c.
Heat Rejection:	300 watts
Data Management:	When unit is on, monitor one temperature sensor and one pressure sensor.
Interfaces:	Connect vent line to space vacuum manifold.

Development Time: 24 months

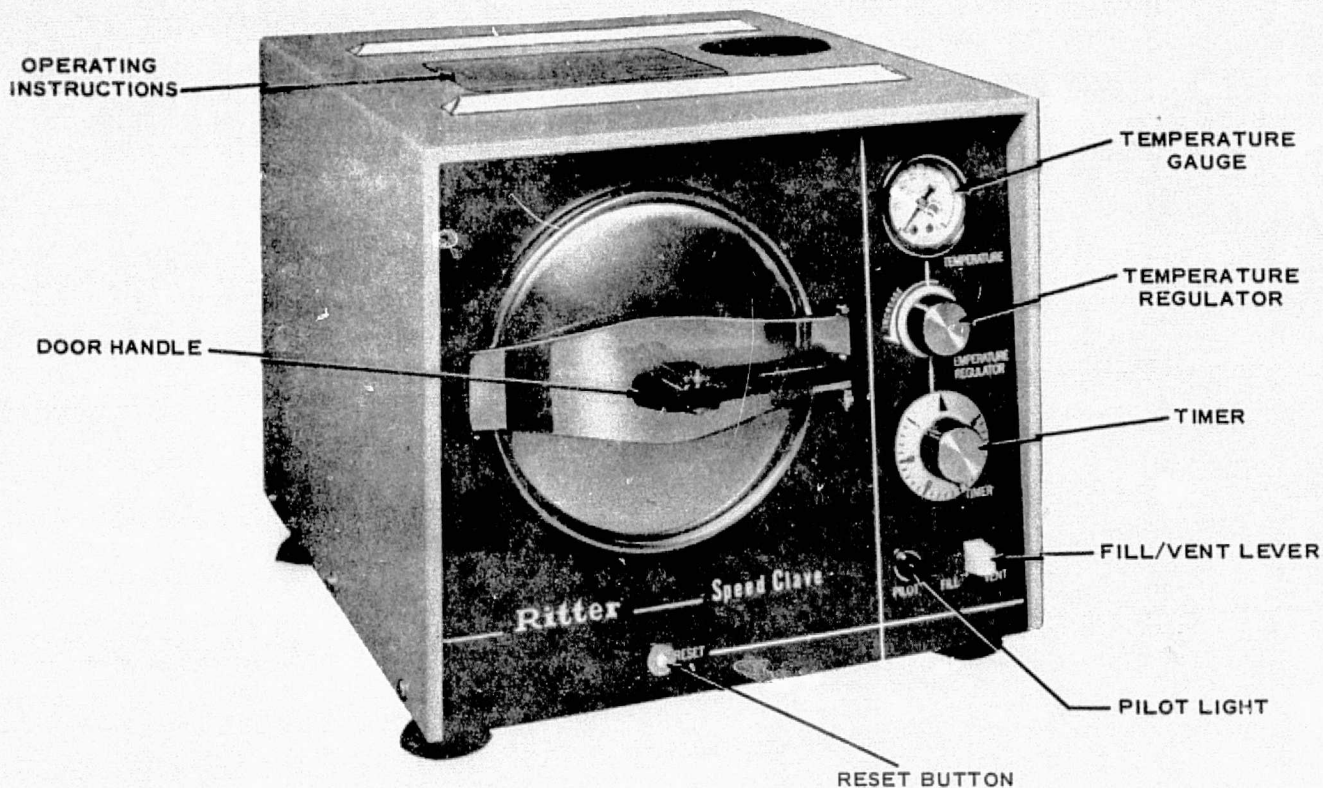


Figure 3. Operating controls

## TECHNICAL SPECIFICATIONS

### SpeedClave Dimensions

18-1/2 Inches Long (Overall)  
13-5/8 Inches Wide (Overall)  
12-3/4 Inches High (Overall)

### Counter Area

16 X 13-5/8 Inches

### Weight

(Without Water) 30-1/2 pounds  
Total Weight (With Water) 33 pounds

### Electrical Rating

115V AC 10 Amps. Standard  
230V AC 5 Amps. Discontinued

### Chamber Capacity

7-1/2 Inches Diameter X 14-1/2 Inches Long

### Tray Sizes

12-5/8 X 6-1/4 X 1	Standard
12-5/8 X 4-3/4 X 1	Optional

**RITTER EQUIPMENT COMPANY, ROCHESTER, N.Y. 14603**  
A DIVISION OF RITTER PFAUDLER CORPORATION

# ALL - AMERICAN

## *Portable* STEAM PRESSURE Sterilizers



CAST ALUMINUM  
CONSTRUCTION

STAMPED ALUMINUM  
SEAMLESS INSET CONTAINER;  
EASY TO CLEAN

CAST ALUMINUM  
CRATE RACK

FLEXIBLE METAL EXHAUST  
TUBE

DIAL GAUGE AND  
VALVE CONTROL

METAL TO METAL SEAL  
(No Rubber Gaskets)

LARGE  
STERILIZING CAPACITY

COMPLETE AND EFFECTIVE  
STERILIZATION AT THE  
LOWEST POSSIBLE COST

### THREE POPULAR SIZES:

No. 1915½ X (15½ qt. liquid cap.), Ship. Wt. 20 lbs.

No. 1925 X (25 qt. liquid cap.), Ship. Wt. 25 lbs.

No. 1941½ X (41½ qt. liquid cap.), Ship. Wt. 39 lbs.

Each sterilizer packed in  
individual corrugated cartons.

ALL-AMERICAN Sterilizers make it possible for all doctors, dentists, first aid stations, hospitals, and laboratories to have fool-proof sterilization facilities at an extremely low cost. Used over any effective heat source, it is only a matter of minutes to secure dry sterile dressings and instruments, with all bacteria and micro-organisms destroyed. Only a small amount of water is needed, and the dry steam at 20 lbs. pressure penetrates all hinges and crevasses in any instrument and makes them sterile in 15 to 20 minutes. No wiping is necessary to remove chemical residue or moisture, and cutting edges are not dulled. Dressings are made sterile in about 30 minutes, and ready for immediate use.

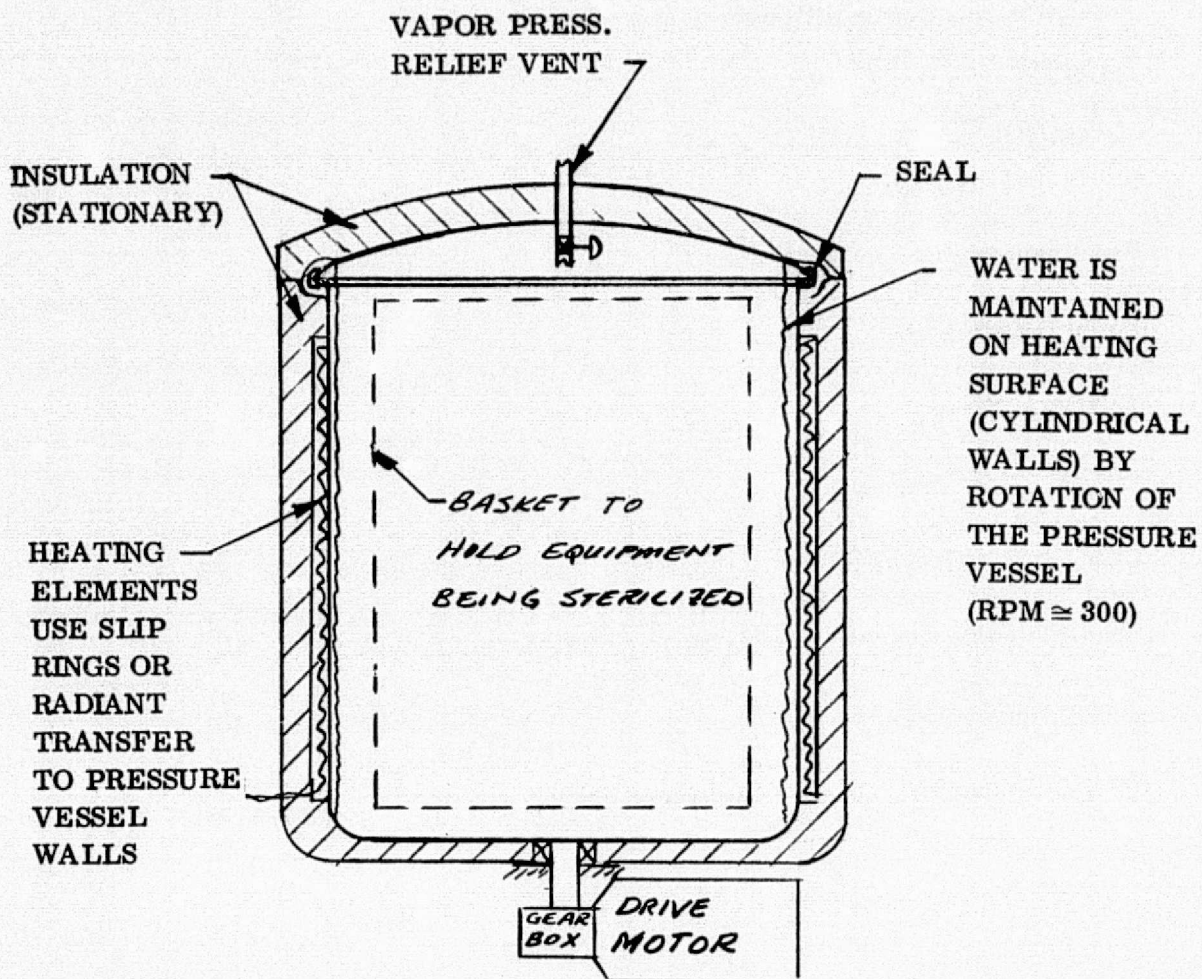
The ALL-AMERICAN Sterilizers are made of high quality cast aluminum alloy, with all the special features of the famous ALL-AMERICAN Pressure Cookers. The metal-to-metal seal eliminates all rubber gaskets. As a safety feature, clamping locks prevent removal of the cover while there is pressure present. An accurate pressure gauge, pressure control valve, over-pressure safety plug, metal air release tubing for quick exhaustion of all air within the Sterilizer, and cool Bakelite handle and wing nuts are all thoroughly tested features that assure safe, fool-proof operation, with a minimum amount of attention.

MANUFACTURED BY  
**WISCONSIN ALUMINUM FOUNDRY CO., INC.**  
MANITOWOC, WISCONSIN

ESTABLISHED 1909

2-250

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Rotating Autoclave Concept for Null Gravity Use

## E.I. 165 STERILIZER, TOOL

(E. U. 6 - Maintenance Repair & Fabrication Unit)

### Purpose

To sterilize miscellaneous small metal hand tools such as scalpels, by means of electrical heating.

### Requirements

To be determined.

### Hardware Status

Rating: Modification

Existing sterilizers should be usable with minor modifications. The attached catalog sheet contains a description of a commercial Bacti-Cinerator sterilizer. The unit would require alteration in order to use 28 volt d.c. power.

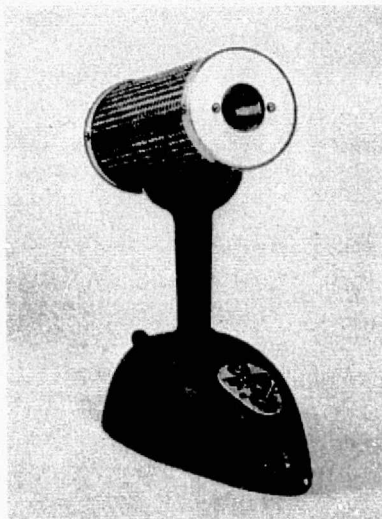
### Technical Description

Estimated properties for a flight unit are:

Weight	1 kg (2.2 lb)
Volume	1 dm <sup>3</sup> (0.035 ft <sup>3</sup> )
Power	110 watts

Development Time: 6 months

**E.I.165    STERILIZER, TOOL (CONT.)**



B9753

**B9753**

**S/P BACTI-CINERATOR**—Sterilizes inoculating loops and needles without the dangerous splattering of pathogenic micro-organisms associated with use of an open gas flame. Ceramic funnel tubing is inert in a carbonaceous atmosphere, and highly resistant to alkaline and other fluxes. Reaches sterilization temperature (1600°F) within 6-minute warmup time. Infrared heat transfers uniformly through entire length of transparent glass tube; incineration of organic matter completed within five to seven seconds. Bacti-Cinerator\* opening flares outward into a funnel for easy insertion of loops, needles and culture tube mouths. Any splattering which does occur is confined so that droplets are incinerated in the tubing, not in the open air. Smooth surface of tubing will not abrade loops or needles, and stainless steel perforated guard protects personnel by dissipating heat rapidly. Heavy, cast aluminum base is finished in baked hammerloid enamel, providing stability and handy storage for six needle holders. Economical to operate, Bacti-Cinerator draws less than 0.9 amps. For operation on 115V, 50/60 Hz, 110 watts.

Order **B9753—Bacti-Cinerator** . . . . . Each **\$56.00**

**B9754**

**ELEMENT, Heating**—Replacement for B9753 S/P Bacti-Cinerator.

Order **B9754—Element** . . . . . Each **\$21.40**

\*TM-Sherwood Medical Industries, Inc.

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E.I. 174 TANK, VERTEBRATE WATER  
(E.U. 42 - Vertebrate Research Support Unit)

Purpose

To store drinking water for the vertebrates.

Requirements

The tank capacity was based on the drinking water requirement of one macaque monkey, which is about 500 g/day. For thirty days the tank would have to contain 15 kg or 15 dm<sup>3</sup>, and a positive expulsion type of tank would be needed. The tank was assumed to include the necessary plumbing and valves in order to transfer the water to the holding units. This tank could also be used to provide water to one small vertebrate holding unit, the requirements of which will be less than 500 g/day.

Hardware Status

Rating: Modification

Flight-qualified positive expulsion tank designs should be available. However, since Spacelab does not provide a source of nitrogen pressure to the experiments, a source of pressure for the liquid expulsion will be needed. This could be provided by a small air pump, a sealed/pressurized unit, or a small pressurized gas bottle (must be protected in the event of fragmentation).

Technical Description

The approximate properties of the vertebrate water tank are:

Weight:

For 30 Days -

Tank, regulators, plumbing, etc.	5 kg
<u>Water for 30 days</u>	<u>15 kg</u>
Total for 30 days	20 kg (44 lb)

For 7 Days -

Tank, regulators, plumbing, etc.	5 kg (using same tank)
<u>Water for 7 days</u>	<u>3.5 kg</u>
Total for 7 days	8.5 kg (18.7 lb)

Envelope Volume: 23.3 dm<sup>3</sup> (1 ft<sup>3</sup>)

Power: 5 watts, 28 volt, d.c.

E.I. 174 (Cont'd)

Heat Rejection:	5 watts to air
Data Management:	Monitor tank pressure
Location:	Near corresponding holding unit
Interfaces:	EPS, CDMS, & holding units (E.I. 103, E.U. 40 and E.I. 101C, E.U. 41)

Development Time - 6 months.

E.I. 175 TANK, PLANT & INVERTEBRATE WATER  
(E.U. 50 - Plant Holding Unit)

Purpose

To provide for plant watering and, if required, invertebrate watering.

Requirements

Total water requirements will vary depending upon the experiments. A maximum requirement of  $1.5 \text{ dm}^3$ /week per plant holding unit was assumed. Invertebrate requirements should be less than this. Thus, the total requirements will be quite small and could most easily be satisfied by means of manually operated, collapsible liquid expulsion bottles. Such bottles, with liquid quantity graduations and a capacity of 750 cc each, were used herein. Individual bottles can be used to supply not only water but also the nutrients needed by the various organisms.

Hardware Status

Rating: Modification

Plastic collapsible drinking containers were used aboard Skylab. Similar bottles could be used for plant watering. They could be used with or without syringes to inject the water into the plant media, depending upon experiment requirements.

Technical Description

The properties of collapsible bottles for plant or invertebrate watering are estimated below.

Weight:

For 30 Days

Bottles (9 reqd.)	0.7 kg
Water	6.4 kg
Total	7.1 kg (15.7 lb)

For 7 Days

Bottles (2 reqd.)	0.2 kg
Water	1.5 kg
Total	1.7 kg (3.75 lb)

Envelope Volume:

For 30 Days	$12 \text{ dm}^3$ ( $0.42 \text{ ft}^3$ )
For 7 Days	$3 \text{ dm}^3$ ( $0.1 \text{ ft}^3$ )

E.I. 175 (Cont'd)

Power & Heat Rejection:	0
Data Management:	Data on time and water volume used will be entered manually into CDMS.
Location & Interfaces:	Plant holding units (E.I. 101, E.U. 50) and plant containers within (E.I. 29, E.U. 50). Invertebrate holding unit (E.I. 98C, E.U. 70).
Operations:	TBD. It should be noted that the general purpose Liquid Storage & Dispensing System (E.I. 114G, E.U. 3) could also provide water for plants and invertebrates, depending upon specific mission requirements.

Development Time - 6 months.

E.I. 178B THERMOCOUPLE INDICATOR  
(E.U. 3 - Life Sciences Experiment Support Unit)

Purpose

To provide for general thermocouple (TC) measurements throughout the life sciences laboratory. Many permanently mounted thermocouples will be monitored through signal conditioners (couplers) by the CDMS. These will not be monitored with the thermocouple indicator but will be read out at the Spacelab or Orbiter CRT/keyboard stations.

Requirements

This indicator should be usable with a number of different but standard types of thermocouples. It should be portable and have a digital readout.

Hardware Status

Rating: Modification.

A number of commercial TC indicators are available which could be modified for space flight use.

Technical Description

Properties of a typical portable TC indicator are summarized below and in the attached catalog sheet.

Weight:	6 kg (13.2 lb)
Dimensions:	15.2 cm W × 23.0 cm H × 27 cm D (6" × 8.9" × 10.6")
Volume:	9.4 dm <sup>3</sup> (.33 ft <sup>3</sup> )
Power:	8 watts (est.) for recharging batteries, 28 volt d.c., 16 hours/day (digital thermometer requires 20 VA when operating).
Heat Rejection:	5 watts
Data Management:	Digital or analog output may be interconnected to the CDMS if desirable
Location:	Portable
Interfaces:	CDMS & EPS. Interconnect to type T, J, E, K, or R thermocouples or to millivolt sources requiring measurement.

Development Time - 6 months.

**Type 2812 BATTERY UNIT**

Type 2809, combined with the Type 2812 Battery Unit, can be used at a portable temperature measuring instrument at places where no AC power is available. With built-in rechargeable nickel-cadmium battery and electronic circuit, the Battery Unit can be fully recharged even during measurement.



Type 2809 combined with Type 2812 Battery Unit

**SPECIFICATIONS**

**Battery:** Code 289904 Nickel-Cadmium Battery (12 V DC)

**Recharging Power Source:** 100, 115, 220, 240 V AC  $\pm 10\%$ , 50 and 60 Hz. Other recharging power sources are available upon request.

**Output Voltage:** 110V (peak value), 100 Hz rectangular waveform

**Continuous Operating Time:** Approx. 120 min. at room temperature

**Recharging Time:** Approx. 15 hours at 100V AC, 50 or 60 Hz

**Battery Voltage Indicator:** Built-in (battery is usable with pointer of indicator resting within green band)

**Operating Temperature Range:** 0 to 40°C (32 to 104°F)

**Dimensions:** Approx. 77×210×252 mm  
(Approx. 3×8¼×9⅞")

**Weight:** Approx. 4.2 kg (Approx. 9.3 lbs)

**Accessories supplied at no extra cost:**

Carrying case .....1 pc.

Instruction manual.....1 copy

**Code 289904 Nickel-Cadmium Battery**

**Nominal Voltage Value:** 12 V DC

**Nominal Capacity:** 3,300 mA/hr. (average of five hours)

**Recharging Current:** Less than 350 mA

**Recharging Time:** 14 to 16 hours

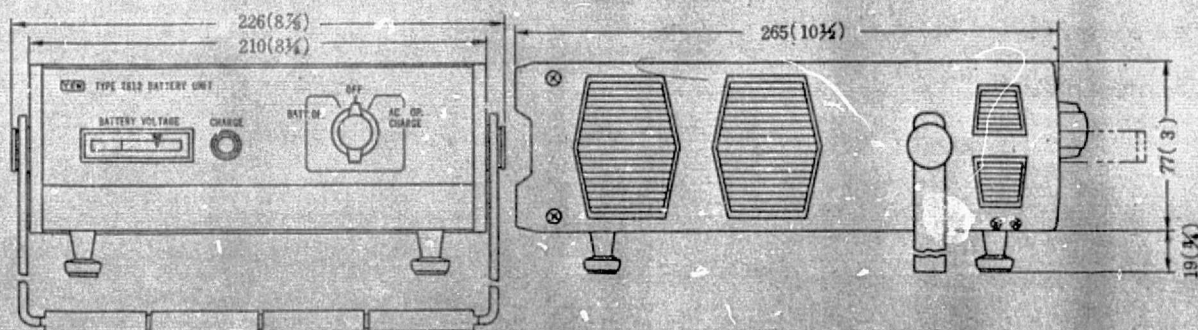
**Max. Rechargeable Voltage:** 15 V

**Dimensions:** Approx. 75×190×69 mm  
(Approx. 3×7½×2¾")

**Weight:** Approx. 1.8 kg (Approx. 4.0 lbs)

**DIMENSIONS**

Unit: mm (inch)



## E.I. 178B (Cont'd)

**SPECIFICATIONS****GENERAL SPECIFICATIONS**

**Operating Principle:** Feedback pulse width modulation counting method (integrating type)

**Display:** 4-digit in-line display (LED)

**Input Terminal:** Floating

**Response Time:** Approx. 1.5 sec. (main unit only)

**Max. Input Voltage:** 10 V DC or AC, common mode voltage; 100 V DC or AC

**Common Mode Rejection:** More than 60 dB at DC and power supply frequency

**Operating Temperature Range:** 0 to 40°C (32 to 104°F)

**Dielectric Voltage:** 500V AC for one minute between input terminal and outer case

**Insulation Resistance:** More than 100 MΩ at 500V DC between input terminal and outer case

**Power Supply Voltage:** 100, 115, 220 or 230V AC  $\pm 10\%$ , 50 or 60 Hz. Other power supply voltages are also available upon request.

**Power Consumption:** Approx. 20 VA

**Dimensions:** Approx. 77×210×256 mm (3×8¼×10⅞")

**Weight:** Approx. 3.2 kg (7.0 lbs)

**Accessories supplied at no extra cost:**

Power cord (2- or 3-pin system).....1 set.

Fuses (0.5A) .....2 pcs.

Carrying case .....1 pc.

Instruction manual .....1 copy

**Types Available**

Code	Description
280900	Multi-range JIS (°C)
280910	Multi-range ISA (°C)
280920	Multi-range ISA (°F)
280930	Multi-range DIN (°C)
280940	Multi-range BS (°C)

The model with a single range (any one out of the above ranges) is available upon request.

**DISPLAY TEMPERATURE IN DEGREES C (°C)**

**Maximum Indication:** 1999

**Unit Marks:** °C and mV

**Measuring Range, Resolution and Input Impedance:**

**Temperature;**

Thermocouples				Measuring Range	Resolution	Input Impedance
ISA	JIS	DIN	BS			
T	CC	Cu-Konst	Copper vs. Constantan	-50 to 199.0°C	0.1°C	15 kΩ
J	IC	Fe-Konst	Iron vs. Constantan	0 to 800°C	1°C	57 kΩ
K	CA	NiCr-Ni	Nickel/Chromel vs. Nickel/Aluminum	0 to 1200°C	1°C	61 kΩ
R	PR-13	Pt 10% Rh-Pt	Platinum/13% rhodium vs. Platinum	0 to 1600°C	1°C	23 kΩ
CrC (ANSI Type E)				0 to 800°C	1°C	76 kΩ

**DC Voltage;**

Range	Measuring Range	Resolution	Input Impedance
20 mV	0 to $\pm 19.90$ mV	10 $\mu$ V	25 kΩ
200 mV	0 to $\pm 199.0$ mV	100 $\mu$ V	250 kΩ

**Accuracy:**

Main unit only, at  $23 \pm 3^\circ\text{C}$

$\pm (0.1\% \text{ of reading} + 1 \text{ digit})$  on mV ranges,

$\pm (0.3\% \text{ of full scale} + 1 \text{ digit})$  on temperature ranges,

$\pm 1.5^\circ\text{C}$  on temperature range of CC ( $-50$  to  $0^\circ\text{C}$ )

**Cold Junction Compensation:** By planar type diode mounted in terminal

Compensation range; 0 to  $40^\circ\text{C}$

Compensation accuracy;  $\pm 1.0^\circ\text{C}$

(provided with Compensation Selector for INT. C.J. or EXT. C.J.)

**Linearizer:** Five types built in

**Analog Output:** Output voltage; 1 mV/digit

Output impedance; Approx. 1 kΩ

Accuracy;  $\pm 0.3\%$  of full scale value

$\pm 10$  mV on temperature range of CC ( $-50$  to  $0^\circ\text{C}$ )

**DISPLAY TEMPERATURE IN DEGREES F (°F)**

**Maximum Indication:** 3999

**Unit Mark:** °F and mV

**Measuring Range, Resolution and Input Impedance:**

**Temperature;**

Thermocouples		Measuring Range	Resolution	Input Impedance
ISA	Type T (CC)	-60.0 to 400.0°F	0.1°F	15 kΩ
	Type J (IC)	0 to 1500°F	1°F	59 kΩ
	Type K (CA)	0 to 2200°F	1°F	62 kΩ
	Type R (PR-13)	0 to 3000°F	1°F	23 kΩ
ANSI Type E (CrC)		0 to 1500°F	1°F	77 kΩ

**DC Voltage;**

Range	Measuring Range	Resolution	Input Impedance
40 mV	0 to $\pm 39.90$ mV	10 $\mu$ V	45 kΩ
400 mV	0 to $\pm 399.0$ mV	100 $\mu$ V	450 kΩ

**Accuracy:**

Main unit only, at  $23 \pm 3^\circ\text{C}$

$\pm (0.1\% \text{ of reading} + 1 \text{ digit})$  on mV ranges,

$\pm (0.3\% \text{ of full scale} + 1 \text{ digit})$  on temperature ranges,

$\pm 1.5^\circ\text{F}$  on temperature range of CC ( $-60$  to  $32^\circ\text{F}$ )

**Cold Junction Compensation:** By planar type diode mounted in terminal

Compensation range; 32 to  $104^\circ\text{F}$

Compensation accuracy;  $\pm 1.5^\circ\text{F}$

(provided with Compensation Selector for INT. C.J. or EXT. C.J.)

**Linearizer:** Five types built in

**Analog Output:**

Output voltage; 1 mV/digit

Output impedance; Approx. 2 kΩ

Accuracy;  $\pm 0.3\%$  of full scale value

$\pm 15$  mV on temperature range of CC ( $-60$  to  $32^\circ\text{F}$ )

2-  
E. I. 179 TEMPERATURE BLOCK  
(E. U. 4 - Preparation & Preservation Unit)

Purpose:

Heating block to maintain constant vial or test tube temperature.

Requirements:

Temperature range: Ambient to  $120^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$

Gravity independent tube retention

Housing to prevent personnel burns

Hardware Status.

Rating: Modification

Slight modification of commercial items may be required.

Technical Description:

Based on the DOW DIAGNOTEST Heating Block shown in the attached catalog sheet.

Weight	4.5 kg (10 lb.)
Dimensions	10.8 cm x 14 cm x 11.8 cm (4-1/4 x 5-1/2 x 4-5/8 in.) (12 holes: 17/32 in. dia. by 2-5/8 in. deep)
Volume:	1.7 dm <sup>3</sup> (0.06 ft <sup>3</sup> )
Power:	200 W
Temperature	
Range	ambient to $140^{\circ}\text{C}$
Control	$\pm 0.5^{\circ}\text{C}$

Development Time: 6 months

# DIAGNOSTEST Heating Block



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The DIAGNOSTEST™ Heating Block is a constant temperature dry bath engineered for precise temperature control from ambient to 140°C. This constant temperature block eliminates the need for a water bath with its consequent annoyances of steam, maintenance of water level, control of algal growth and mineral deposition.



## FAST HEAT-UP TIME

When set at 37°C. or 100°C. the DIAGNOSTEST Heating Block reaches temperature equilibrium within 6 to 30 minutes respectively.

## ACCURATE

The high quality, low-differential thermoregulator maintains temperature control of  $\pm 0.5^\circ\text{C}$ . from hole to hole throughout the operable range. Holes precisely dimensioned for the DIAGNOSTEST reagent vials assure rapid and uniform heat transfer.

## VERSATILE

The heating block can be set to any temperature up to 140°C. The pilot light will go out when the block has reached the temperature preset with the screw on the front of the unit.

## RUGGED CONSTRUCTION

The solid, cast-aluminum heat sink block has an insulated bottom cover, dual heater and adjustable thermoregulator. The epoxy resin finish is chemical and heat resistant.

## SPECIFICATIONS

**ELECTRICAL SYSTEM:** 115 volts A.C.  
50-60 cycles per second  
200 watts  
8 ft. 3-wire cord with adapter plug

**HEATING RANGE:** Ambient to 140°C.  
Temperature control maintained to  $\pm 0.5^\circ\text{C}$ .

**BLOCK:** Solid aluminum block with grey epoxy finish  
Shipped with a  $\frac{3}{4}$ " thick vulcanite fiber insulating pad

**DIMENSIONS:** Overall:  $4\frac{1}{4}$ " x  $5\frac{1}{2}$ " x  $4\frac{1}{4}$ "  
12 Holes:  $17/32$ " diameter  
 $2\frac{1}{4}$ " depth

**WEIGHT:** 10 lbs.

## Warranty

The DIAGNOSTEST Heating Block is warranted against defects in material and workmanship for one year from date of delivery, and any such defects not resulting from abuse or carelessness by user will be repaired free of charge.



E.I. 179D THERMOMETER, ELECTRONIC  
(E.U. 5 - Biochemical & Biophysical Analysis Unit)

Purpose

Provides for accurate temperature measurements within the life sciences laboratory.

Requirements

1. Accuracy:  $\pm 0.1^{\circ}\text{F}$  (for organism temperature measurements).
2. A portable unit would be desirable.
3. Digital output would be desirable.

Hardware Status

Rating: Modification.

Commercially available electronic temperature indicators are very numerous. However, those for use with thermocouples are generally not accurate enough to measure organism temperatures. A platinum resistance digital thermometer will produce the accuracies desired and one such instrument manufactured by Doric Scientific Corp. is described below. Doric is currently developing a smaller platinum resistance thermometer with an LED display. Such a unit could probably be modified for spaceflight use.

Technical Description

The Doric Digital Thermometer, Model DS-100-T5, properties were used for this study. The unit has the following properties:

Weight:	5.4 kg (12 lb)
Dimensions:	11.4 $\times$ 21.6 $\times$ 35.6 cm (4.5" $\times$ 8.5" $\times$ 14")
Volume:	8.7 dm <sup>3</sup> (0.31 ft <sup>3</sup> )
Power:	14 watts (Can be modified to operate on 28 volt d.c.)
Heat Rejection:	14 watts
Data Management:	Manual readout - BCD output can be connected to CDMS if desired (max. rate = 2 readings/sec).
Location:	Should be movable to various sites throughout the laboratory (e.g., to the work and surgical bench (E.I. 188, E.U. 5), the holding units, the glove box (E.I. 18, E.U. 4), etc.) A battery pack is available but is quite heavy.
Interfaces:	EPS plug-in at various locations required. CDMS interconnection may be required.

Development Time: 6 months

# KEY PERFORMANCE SPECIFICATIONS FOR DS-100-T5

(Include these specifications with your requisition to be sure you get the instrument you want)

## INPUT CIRCUIT:

Guarded, differential.

## MEASUREMENT METHOD:

Automatic zeroing, dual slope true integration with no possibility of zero foldover errors;  $E_X/E_{REF}$  switching in front of input pre-amplifier.  $E_{REF}$  derived from excitation power supply.

## COMMON MODE REJECTION:

Greater than 120 db (1,000,000 to 1) above 59 Hz with 100 ohms unbalance, 250 VDC or AC CMV.

## OVERALL ACCURACY:

Depends upon range. See tables on Pages 8 & 9.

## NORMAL MODE NOISE REJECTION:

Minimum 50 db at 60 Hz ( $\pm 15\%$ ) increasing at 18 db/octave from 30 Hz with infinite noise rejection every 10 Hz.

## LINEARIZATION:

100% digital with no analog approximation circuits; 10 segments minimum; 20 segments option. Each segment must have resolution of 1 part in 2048 (11 bits).

## LONG TERM STABILITY:

$\pm 0.01\%$  rdg. for 30 days;  $.03\%$  rdg. for 6 months.

## SENSITIVITY:

1 microvolt.

## OVERLOAD:

100V continuous without damage; accidental connection of AC line across input will not damage.

## SPEED:

500 ms complete with full scale step change. Front panel adjustable display rate from 2 readings per second to 1 per 10 seconds.

## TEMPERATURE STABILITY:

$\pm 0.003\%$  rdg./ $^{\circ}\text{F}$ ,  $\pm 0.3\mu\text{V}/^{\circ}\text{F}$  max

## ZERO DRIFT:

None, automatic zero drift correction with each encoding.

## INTERNAL REFERENCE:

Excitation power supply for temperature sensor also serves as reference in ratiometric measurement.

## POLARITY:

Automatic; true indication regardless of instantaneous spikes during sampling.

## DISPLAY:

200,000-hour life, Nixie indicators, smooth non-segmented numerals. Readable to 40 feet. Storage to prevent blur.

## CIRCUITRY:

All silicon, solid state with no mechanical devices at all; all integrated circuits are standard.

## SIZE:

Half-rack, 4.5 by 8.5 inch panel, 12 pounds.

## AC POWER:

105-124 VAC (or 220V) 50-400 Hz; 14 watts.

## OPERATING TEMPERATURE:

Normal accuracy from 50 to 104 $^{\circ}\text{F}$  (10 to 40 $^{\circ}\text{C}$ ); reduced accuracy from 31 to 140 $^{\circ}\text{F}$  (0 to 60 $^{\circ}\text{C}$ ).

## CALIBRATION:

2 or 3 point calibration. At ice point and full scale; individual segment calibration not required as they are digitally established and cannot drift.

## CALIBRATION DATA:

(Optionally furnished) Tables to define worst case errors at 5 $^{\circ}$  increments throughout the calibrated range.

## EXPANSION CAPABILITY:

Same basic digital indicator to accept multi-range DVM and other plug-ins.

## RESOLUTION:

Depends upon range. See Pages 8 & 9.

## REPEATABILITY:

$\pm 1$  digit, any range.

## LEAD WIRE EFFECTS:

Automatic compensation. Less than .02 degrees per ohm of lead wire change with a 4 wire measurement.

## SENSOR EXCITATION CURRENT

10.00 ma for	.25 Ohm $R_o$ sensors
1.00 ma for	10.0 Ohm $R_o$ sensors
1.00 ma for	25.5 Ohm $R_o$ sensors
1.00 ma for	100. Ohm $R_o$ sensors
.50 ma for	200. Ohm $R_o$ sensors
.25 ma for	400. Ohm $R_o$ sensors
.20 ma for	500. Ohm $R_o$ sensors
.10 ma for	1000. Ohm $R_o$ sensors

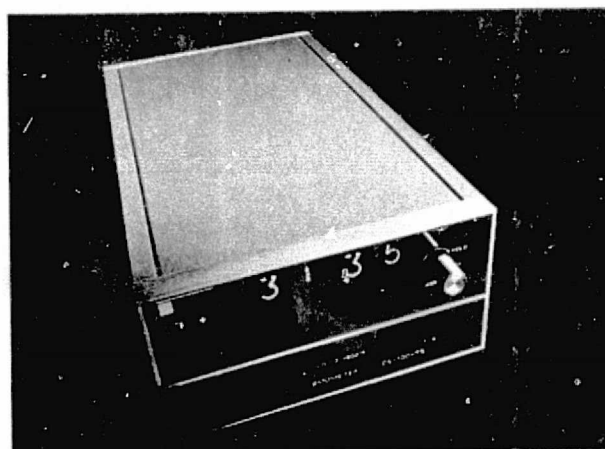
## NOTE:

INPUT CONNECTOR: Amphenol 14-pin P/N 57-30140 mating connector included; except when instrument ordered for 25.5 ohm 162C type primary standard. Then five-way binding posts are substituted.

## MODEL DS-100-T5 RANGES IN °F

RANGE NUMBER	TEMPERATURE RANGE,	OVERALL INSTRUMENT ACCURACY (°F)*		RESOLUTION & REPEATABILITY		NUMBER OF LINEARIZATION SEGMENTS
		ACCURACY	SPAN	STANDARD	OPTIONAL	
PRT12	0 to +100°F	±.035		0.01	0.005	10
PRT13	0 to +200°F	±.060		0.01		10
PRT02	0 to +300°F	±.090		0.1	0.05	10
PRT14	0 to +400°F	±.124		0.1	0.05	10
PRT15	0 to +600°F	±0.1 ±.203	0 to +300°F +300 to +600°F	0.1	0.05	10
PRT10A	0 to +600°F	±0.1 ±.149	0 to +400°F +400 to +600°F	0.1	0.05	20
PRT16	0 to +800°F	±0.2 ±.284	0 to +510°F +510 to +800°F	0.1	0.05	10
PRT44A	0 to +800°F	±0.1 ±.204	0 to +400°F +400 to +800°F	0.1	0.05	20
PRT17	0 to +1000°F	±0.25 ±.392	0 to +530°F +530 to +1000°F	0.1	0.05	10
PRT18	0 to +1200°F	±0.3 ±.516	0 to +350°F +350 to +1200°F	0.1		10
PRT45A	0 to +1200°F	±0.2 ±.312	0 to +700°F +700 to +1200°F	0.1		20
PRT09A	0 to +1400°F	±0.25 ±.378	0 to +800°F +800 to +1400°F	0.1		20
PRT19	0 to +1500°F	±0.5 ±.753	0 to +640°F +640 to +1500°F	0.1		10
PRT18A	- 100 to +200°F	±.04 ±.06	- 100 to +100°F +100 to +200°F	0.01		20
PRT13A	- 200 to +200°F	±.063				
PRT31A	- 200 to +400°F	±0.063 ±.124				
PRT32A	- 200 to +600°F	±0.063 ±.203				
PRT33A	- 200 to +800°F	±0.063 ±.284				
PRT34A	- 200 to +1000°F	±0.063 ±0.25 ±0.392				
PRT35A	- 200 to +1200°F	±0.063 ±0.3 ±0.516				
PRT36A	- 200 to +1500°F	±.063 ±0.5 ±0.753				
PRT50A	- 320 to 0°F	±.08				

## MODEL DS-100-T5



\*For system accuracy, sensor errors such as self-heating, stem conduction, system calibration and repeatability must be added for each application. Consult factory for a detailed error analysis for your application.

E.I. 180 TIMER, EVENT

(E. U. 2 - Data Management Unit)

Purpose

To time various experiment procedures.

Requirements

The requirements of this device were assumed to be met by an existing space qualified timer which is described in the following reference:

"Handbook of Pilot Operational Equipment for Manned Space Flight," Report No. CD42-A/SL-997, Flight Crew Integration Division, NASA/JSC, Houston, Texas, June 1973.

Hardware Status

Rating: Space Qualified

Technical Description

See the attached descriptive sheet from the reference quoted above.

Weight	0.18 kg (0.4 lb)
Volume	0.2 dm <sup>3</sup> (0.007 ft <sup>3</sup> )

Development Time: 6 months.

E.I. 181D TRANSDUCER, PRESSURE  
(E.U. 2 - Data Management Unit)

Purpose

For general purpose pressure measurements throughout the life sciences laboratory.

Requirements

General purpose measurements would generally fall in the range of 0-1000 kN/m<sup>2</sup>  
(0-145 psia).

Hardware Status

Rating: Repackage

These measurements can probably be made with available transducers which are rated for space or aircraft use. Two pressure transducers combined with signal conditioning electronics which were used on Apollo are shown in the attached sheets.

Technical Description

Estimated properties are:

Weight:	0.2 kg (0.44 lb)
Volume:	0.4 dm <sup>3</sup> (0.01 ft <sup>3</sup> )
Power:	1 watt
Heat Rejection:	1 watt
Data Management:	Digital or analog output to CDMS could be provided. Low sampling rate would generally be satisfactory.
Interfaces:	CDMS, EPS

Development Time: 6 months

# PRESSURE TRANSDUCER (APOLLO P/N 837016)

## PURPOSE

The pressure transducer measures the static pressure in the gas supply line.

## DESCRIPTION

The transducer is powered by the 28 vdc supply of the spacecraft and operates over a range of 0 to 150 psig (referenced to cabin pressure). An electrical signal (0 to 5 vdc) proportional to the pressure of the oxygen for the crew's visual information, via an indicator, and for telemetry data to be transmitted to a ground station.

## PERFORMANCE AND DESIGN DATA

Operating range	Gaseous $O_2$ at 0 to 150 psig and from 0° to 150°F
Accuracy, psig	$\pm 3.75$ ( $\pm 0.125$ v)
Output signal	Proportional to sensed pressure. 0 v at 0 psig to 5 vdc at 150 psig. Output signal shall not exceed 6.5 v in the event of over-pressurization.
Output ripple, mv rms	Ripple component of output signal shall not exceed 10
Output load, ohms	30,000
Output impedance, ohms	500 (max)
High pressure fitting end	MS 33656-2 (1/8-in. OD tube)
Proof pressure, psig	225 at 70°F
Burst pressure, psig	375 at 70°F
External leakage	$6 \times 10^{-6}$ lb/hr $O_2$ max with 150 psig internal pressure at 70°F

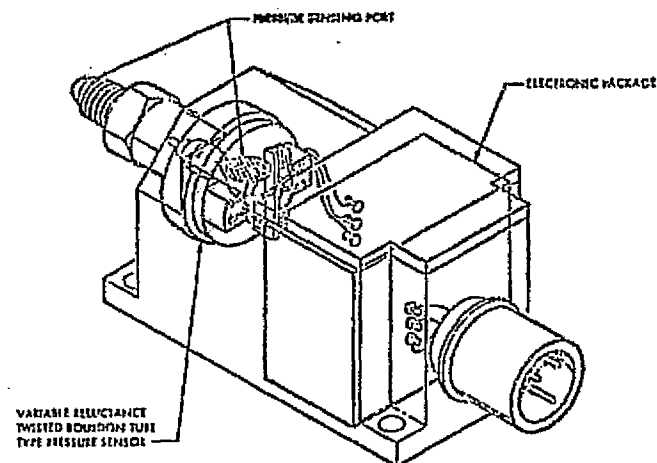
## Electrical power requirements

Input voltage, vdc	28/SS-1070
Excitation current, ma	25 (max)

Weight, lb	0.5
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## QUALIFICATION STATUS

The pressure transducer is a qualified Block II Apollo component.



OXYGEN PRESSURE TRANSDUCER

**PRESSURE TRANSDUCER  
(APOLLO P/N 837036)**

**PURPOSE**

The pressure transducer measures the static pressure of the fluid in the discharge duct.

**DESCRIPTION**

The transducer is powered by the 28 vdc supply of the spacecraft and operates over a range of 0.05 to 0.25 psia. An electrical signal (0 to 5 vdc) proportional to the absolute pressure of the fluid is provided by the transducer. This signal is used for ground checkout, for the crew's visual information, via an indicator, and for telemetry data to be transmitted to a ground station.

**PERFORMANCE AND DESIGN DATA**

Sensed media	Low pressure gas
Accuracy, psi	$\pm 0.005$ ( $\pm 0.125$ v)
Time constant of output signal	Minimum
Output signal	Proportional to sensed pressure, 0 v at 0.05 psia to 5.0 vdc at 0.25 psia. Output signal shall not exceed 6.5 v in the event of overpressurization.
Output ripple, mv rms	Ripple component of output signal shall not exceed 10
Output load, ohms	30,000
Output impedance, ohms	500 (max)
Hermetically sealed	No external adjustments
Proof pressure, psia	22.5 at 70°F
Burst pressure, psia	37.5 at 70°F
Sensing port	HS 33656-4 (1/4-in. OD tube)
Leakage	$6 \times 10^{-4}$ lb/hr $O_2$ max with 20.7 psia external pressure and 14.7 psia internal pressure

**Electrical power requirements**

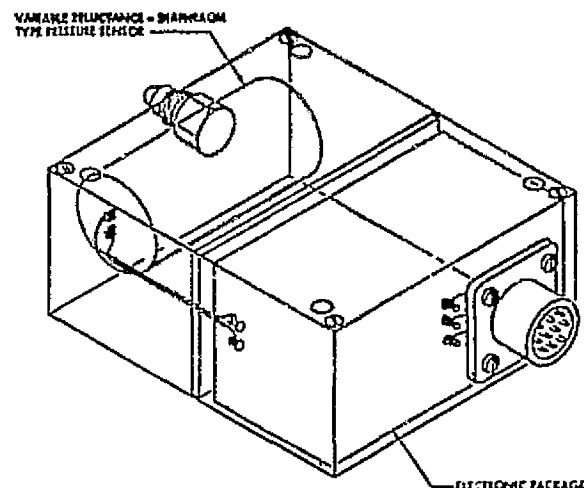
Input voltage, vdc 28 per AIR Research Report 55-1070

Excitation current, ma 40 (max)

Weight, lb 0.65

**QUALIFICATION STATUS**

This pressure transducer is a qualified Block II Apollo component.



**PRESSURE TRANSDUCER**

E.I. 182E URINE VOLUME MEASUREMENT SYSTEM  
(E.U. 31 - Biomedical Research Support Unit)

Purpose

To automatically measure the volume of human urine and provide samples for preservation. The system could possibly be adapted for use with primates.

Requirements

This equipment item is based upon the General Electric Biowaste Monitoring System (BMS) currently being developed for the Shuttle Orbiter under the direction of NASA/JSC. The requirements of the BMS include:

1. Collection, measurement, and sampling of urine from both male and female crew persons in null gravity.
2. A measurement range for a single micturation of 35 to 1000 ml (less than 35 ml cannot be measured).
3. Designed for 6 men.
4. Maximum capacity of 4000 ml/man-day.
5. Each micturation to be measured with an error of less than  $\pm 2\%$ .
6. Samples of  $20 \pm 5$  ml at the option of the user to be extracted manually from each micturation.
7. The main volume of urine is to be transported to the Shuttle Orbiter waste collection system for subsequent transfer to the waste liquid storage tanks.

More complete requirements are given in an end item specification which is contained in Ref. #2, cited below.

Hardware Status

Rating: New Development

The development of this equipment is being sponsored by the Life Sciences Directorate of NASA/JSC. The NASA contract technical monitor is Mr. R. L. Sauer (Tel. 713/483-5191). The contractor is G.E., Space Division, Valley Forge, PA. A system prototype has been built but is still in the process of undergoing minor changes. This system is being designed for incorporation into the Shuttle Orbiter. However,

it has potential for use within the life sciences laboratory in the event it is not carried in the Orbiter. It also has potential for use with the primate holding units. For these reasons, it is being included in the life sciences laboratory equipment inventory.

### Technical Description

The system employs a funnel-shaped urine collector through which air is drawn in order to entrain the urine and carry it to the phase separator. The vortex type phase separator is motor driven at 400 rpm by a gear box and a 115 volt, 400 Hz motor. It contains rpm, airflow, and liquid pressure sensors which provide diagnostic and control information to the system electronics. The urine is transferred from the separator to a volume measurement assembly. This assembly employs a motor driven positive displacement proportioning device. Two piston chambers are alternately filled with urine and then discharged, either to a sample container or to the shuttle waste liquid storage system. Maximum discharge pressure is automatically limited to about 10 psi.

Preliminary properties of the urine collection and volume measurement system are given below. Some of this information was taken from the references listed below. Other properties were not available and were estimated.

Weight and Power:	<u>kg</u>	<u>watts (peak)</u>
Urine collection & measurement hardware	18.6	161
Flush water, biocide, tankage & plumbing (estimated) (water for 24 hours of use must be provided; remaining water is to be provided from the Shuttle fuel cells, Ref. 2)	10	14
Totals for 6 men (7- & 30-day weights are approximately equal due to the use of fuel cell water)	28.6 (63)	175 watts, 115 volt, 400 Hz & 25 volt d.c.
Volume:	46 dm <sup>3</sup> (1.6 ft <sup>3</sup> ) estimated	
Heat Rejection:	Heat output averaged over 24 hours is 13 watts, based upon average usage rate of 7 times per day per man.	

E.I. 182E (Cont'd)

Data Management:

Data processing and unit control is performed by an integral microprocessor. The unit includes a display and control module with visual display of operational status. The urine measurement system will provide volume measurement data correlated with the corresponding user and sample container identification. This data will be transmitted to the CDMS for transmission to ground.

Location:

Currently planned to be placed aboard the Shuttle Orbiter.

Interfaces:

1. Water from the Orbiter fuel cell is required at a rate of about 3.2 kg/day for 6 man use.
2. Urine will be fed to the waste collection system at about 12 kg/day for 6 man use.

Operations:

Average on-time will be 2-1/2 minutes per micturation and the average number of micturations will be 7/day per man. The urinal can be used in a seated or standing position.

Development Time: 18 months.

References

1. Modular Biowaste Monitoring System, Conceptual Design Report, Report No. 74SD4254, Contract NAS9-13748, General Electric, Space Division, Valley Forge, Pa., October 1974.
2. Modular Biowaste Monitoring System for Shuttle Orbiter, Report No. 75SDS4203, Contract NAS9-13748, General Electric, Space Division, Valley Forge, Pa., December 1974.

## E. I. 182J VCG COUPLER

(E. U. 31 - Biomedical Research Support Unit)

### Purpose

To condition VCG voltage signals for transmission to the CMDS, recording devices, or display devices.

### Requirements

### Hardware Status

Rating: Re-package

Existing electronics components and packaging designs should be usable. A VCG system was flown aboard Skylab.

### Technical Description

Estimated properties of a VCG coupler are:

Weight:	0.2 kg (.44 lb)
Volume:	0.5 dm <sup>3</sup> (0.013 ft <sup>3</sup> )
Power:	2 watts
Heat Rejection:	2 watts (to air)

Data Management: The CDMS sampling rate required will depend upon the organism being monitored. The rate used for preliminary purposes was 500 samples/sec. per channel (7 bits per sample)

Location: VCG couplers should be located close to the source of the VCG signals. They will be located within the holding units for primates.

Interfaces: Structural interfaces may exist between these couplers the holding units, and various spacelab racks. Electrically interfacing items include the crew, the organisms, the CDMS (RAUs) the strip chart recorder (EI 150A, E. U. 1) and the oscilloscope (EI 132, E. U. 2).

Development Time: 6 months

E.I. 182P VENTILATION UNIT, VERTEBRATE  
(E.U. 42 - Vertebrate Research Support Unit)

Purpose

The purpose of this unit is to provide for ventilation of the vertebrate holding units. It differs from the vertebrate ECS (E.I. 182R, E.U. 42) in that the ventilation loop is open to the cabin atmosphere. It would be used where man-surrogate testing required the vertebrates to be subjected to the same atmosphere as that of the crewmen.

Requirements

The general requirements used in estimating the properties of the ventilation unit included:

1. Sized to support two small vertebrate holding units (E.I. 103, E.U. 40) or one primate holding unit (E.I. 101C, E.U. 41).
2. Assumed to require LiOH for CO<sub>2</sub> removal in order to function independent of cabin CO<sub>2</sub> removal system.
3. High pressure O<sub>2</sub> required to make up for Spacelab O<sub>2</sub> consumed by vertebrates.
4. Odor and particulate filtration required before air returned to cabin.

Hardware Status

Rating: New development.

This unit will have to be designed, fabricated, tested and qualified. However, hardware qualified for space flight or for aircraft applications may be available for use. The ventilation unit will be the subject of studies in conjunction with the two current NASA/MSFC contracts, each entitled Conceptual Design for a Biological Holding Facility. These contracts were awarded in May of 1975, and thus design of a ventilation unit for vertebrate support will have to await the outputs from these studies. For purposes of this study, in-house estimates have been made and are presented below.

Technical Description

The ventilation unit will draw in air from the cabin atmosphere, or possibly from a fresh air cabin ECS duct in order to obtain relatively cool, dry air. However, the

## E.I. 182P VENTILATION UNIT, VERTEBRATE (Cont'd)

unit should provide air to the vertebrates of equal temperature, pressure, and composition to that experienced by the crew. The unit will consist of ducting, blowers, valves, gaseous and particulate contaminant filters, LiOH for CO<sub>2</sub> removal, and gaseous oxygen to make up for the oxygen consumed by the vertebrates. The LiOH and O<sub>2</sub> supply functions could be integrated with the cabin ECS, but this has not been assumed here in order to be on the conservative side regarding estimated weights and volumes. The amount of LiOH and O<sub>2</sub> required will not be large for individual organisms, but many payloads will carry multiple organisms. For example, a load of 6 macaques would require the O<sub>2</sub> equivalent of about 1.7 men.

Air re-entering the cabin will be filtered through LiOH, activated charcoal, and a fine particulate filter. This will minimize gaseous, particulate, and bacterial contamination of the cabin. It was assumed that water vapor introduced into the air by the vertebrates would be removed by the Spacelab condensing heat exchanger. This assumption was made because low temperature coolant (required for dehumidification) is not available to the experiments.

The following properties were estimated for a vertebrate ventilation unit which was sized to service either 16 rats or 1 primate.

Item	Weight, kg (lb)	Volume, dm <sup>3</sup> (ft <sup>3</sup> )	Power, watts
<u>7-DAY MISSION</u>			
Fixed hardware (ducting, blowers, valves, instrumentation, structure)	8.5	17.0	40
Mission-dependent LiOH canisters, oxygen, tankage & filters	10.5	15.7	0
Totals for 7-Day Mission	19.0 (42)	32.7 (1.2)	40
<u>30-DAY MISSION</u>			
Fixed hardware	8.5	17.0	40
Mission-dependent LiOH canisters, oxygen tankage & filters	42.0	62.8	0
Totals for 30-Day Mission	50.5 (111)	79.8 (2.82)	40

Heat Rejection: 80 watts (includes 40 watts of metabolic heat) to the cabin air.

E.I. 182P VENTILATION UNIT, VERTEBRATE (Cont'd)

Data Management:

Monitor:

- 6 thermocouples @ 285 to 355°K, two times per minute
- 4 pressure sensors, once per minute
- 2 switches (bi-level), once per minute
- 1 amperage reading, once per minute
- 1 gas flow meter, once per minute

Location:

The vertebrate ventilation unit should be located adjacent to the holding units. The high pressure oxygen bottles may have limitations on their location from a safety standpoint.

Interfaces:

- (1) Draw air from cabin or cabin ECS (about 33 kg/hr)
- (2) Interconnect gas sample lines to gas analyzer, mass spectrometer (5/91) for vertebrate inlet and outlet gas monitoring.
- (3) Bleed make-up oxygen into the cabin at a rate equal to the usage by the vertebrates (about 0.29 kg/day for 16 rats)
- (4) Ventilation unit will add water vapor to the cabin air at a rate of about 35 g/hr.

Development Time: 24 months.

E.I. 182R VERTEBRATE ENVIRONMENTAL CONTROL SYSTEM (ECS)  
(E.U. 42 - Vertebrate Research Support Unit)

Purpose

To provide a closed loop air circulation system for the primate and small vertebrate holding units.

Hardware Status

Rating: SRT

This ECS system is currently the subject of studies being funded by NASA and monitored out of MSFC. Two parallel studies entitled Conceptual Design for a Biological Holding Facility are being performed. Although the vertebrate ECS will have to be specially designed and built to satisfy the vertebrate requirements, existing space-qualified hardware may be usable for some components. Such components would include heat exchangers, condensers, gas storage bottles, LiOH canisters, blowers, controllers, etc.

Technical Description

A preliminary concept for a closed ECS is shown in the attached schematic. The system contains LiOH for CO<sub>2</sub> removal, blowers for air recirculation, a condenser/separator for dehumidification and cooling, and high pressure oxygen bottles. It should be noted that water for the vertebrates is provided by E.I. 174, Tank, Vertebrate Water (E.U. 42), and food for the vertebrates is assumed to be contained in the holding units (E.I.s 101C & 103). Activated charcoal (odor absorbing) filters were also assumed to be incorporated in the holding units.

Referring to the ECS flow schematic, the LiOH canister is placed in parallel with the loop blowers to minimize canister size as well as pressure drop. The loop is maintained slightly below cabin atmospheric pressure, so that any leakage will occur into the organism holding units and minimize the possibility of cabin contamination. The leakage that does occur will be vented to the cabin contaminant control system through the pressure control valve. Humidity is controlled in the cage modules by controlling the temperature of the cooler/condenser, which in turn controls the dew point temperature of the air leaving the cooler. The air temperature is controlled by varying the ratio of air bypassing the cooler to that flowing through it.

The ECS concept configuration and sizing were based upon a common system to serve for both primates and small vertebrates. The basic system was sized to support 1 macaque monkey or 16 rats. Thus, the system would ventilate one primate holding unit (E.I. 101C) or two small vertebrate holding units (E.I. 101). The approximate weight, power and volume of the vertebrate ECS are listed below. These values were based upon the use of a thermoelectric cooler/condenser. This unit accounts for about 200 watts of the total power requirement (320 watts) of the ECS. A thermoelectric unit was used since the Spacelab does not currently provide for low temperature coolant to experiments. If such coolant were available at about 45°F, the 200 watt cooler power requirement could be eliminated.

Item	Weight, kg	Volume, dm <sup>3</sup>	Power, watts
<u>7-DAY MISSION</u>			
Fixed hardware (plumbing, condenser/ separator, blowers, etc.)	28	105	320
Duration dependent LiOH canisters + oxygen & tankage	10	16	0
Totals for 7-Day Mission	38 (83.8 lb)	121 (4.27 ft <sup>3</sup> )	320 (28 v d.c.)
<u>30-DAY MISSION</u>			
Fixed hardware	28	105	320
Duration dependent LiOH canisters + oxygen & tankage	44	65	0
Totals for 30-Day Mission	72 (158.7 lb)	170 (6.0 ft <sup>3</sup> )	320 (28 v d.c.)

## Heat Rejection:

353-367 watts (includes 47 watts for 16 rats or 33 watts for one monkey, of metabolic heat) to experiment provided coolant loop rejecting heat to the Spacelab experiment heat exchanger.

## Data Management:

## Monitor -

10 thermocouples @ 270 to 355°K, on average about twice per minute

6 pressure sensors, variable pressure, on average of once a minute each

6 switches (bi-level), twice a minute each

4 amperage readings, twice a minute each

4 gas flowmeters, twice per minute each

E.I. 182R (Cont'd)

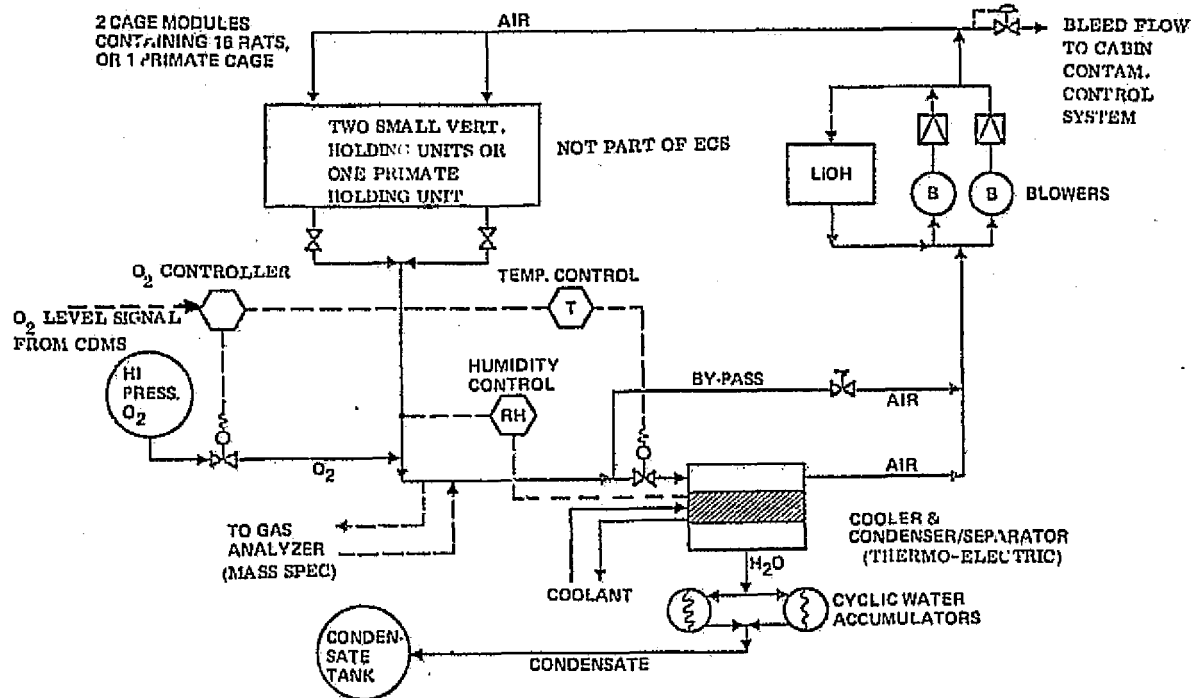
Location:

The vertebrate ECSs should be located near their respective holding units and near the gas analyzer, mass spectrometer (E.I. 91, E.U. 5). The high pressure oxygen bottles may be subject to limitations on their location.

Interfaces:

- (1) Interconnect over-pressure bleed port to Spacelab crew ECS contaminant removal system.
- (2) Interconnect cooler/condenser to coolant loop and Spacelab experiment heat exchanger.
- (3) Interconnect gas sample lines to gas analyzer, mass spectrometer (E.I. 91, E. U. 5).

Development Time: 42 months.



ECS Loop Concept for Vertebrate Holding Units

E.I. 185 MULTIMETER  
(E. U. 6 - Maintenance Repair and Fabrication Unit)

Purpose

To make electrical measurements and continuity checks. It would be used for experiment measurements as well as maintenance and repair functions.

REQUIREMENTS

Alternating current and direct current measurements will be required within the following estimated minimum and maximum values:

Voltage	1 mV to 300 V
Amperage	1 $\mu$ A to 10 amps
Resistance	10 ohms to 10 Mohms

The actual ranges needed will be a function of the specific requirements as well as the type of power available on the supporting vehicle. A portable instrument would be desirable for some measurements, but this feature is not mandatory.

Hardware Status

Rating: Modification

Commercial units should be adaptable for flight. Modifications might include (1) the type of power used, (2) design alteration needed to survive launch vibrations and loads, and (3) component alteration meet thermal and vacuum requirements associated with operation in the space vehicle environment. A Simpson Model 360 digital VOM is briefly described in the attached catalog sheet. This meter or one similar to it could probably be adapted for flight.

Skylab carried a digital multimeter kit which weighed 1.93 kg (4.25 lb) and might be suitable for use. Also, Beckman studied the applicability of using a Fluke 8200A Digital Voltmeter in the space environment (see Ref. cited below).

Technical Description

The weight, volume and power of the Simpson Model 360 is summarized below:

Weight	2.0 kg (4.5 lb) (with batteries)
Size:	18.3 cmH $\times$ 13.7 cmW $\times$ 9.5 cmD (7.2 $\times$ 5.4 $\times$ 3.75 in.) (not including front panel controls)
Volume	2.39 dm <sup>3</sup> (0.084 ft <sup>3</sup> )
Power	0 (battery)

E.I. 185 (Continued)

Development Time: 6 months

Reference

Analysis of Multipurpose Equipment for Space Application, Contract No. NAS8-29776 (NASA/MSFC), Bechman Instruments, Inc., Advanced Technology Operations, 10 December 1973.

## E.I. 185 MULTIMETER (Cont'd)



# Simpson 360

### DIGITAL VOM

Supplied with test leads, AC line cord, (less batteries) and with operator's manual. . . . . \$275

Carrying Case, Catalog No. 00815 . . . . . \$1950

360 for 220 VAC/50Hz operation (less batteries) . . . . . \$280

### SPECIFICATIONS

#### • MAXIMUM COMMON MODE:

Voltage: 600V (DC plus peak AC) from "COMMON" terminal to third wire power line ground terminal

#### • DISPLAY:

Numerical Display: 3½ digits, 7-segment, 0.33 inch high LED type, non-blinking with storage  
Conversion Rate: 5 readings per second, nominal  
Overrange Indication: Automatic beyond 1999, with lower half of the "1" digit flashing  
DC Polarity Selection: Automatic, with "+" or "-" indication  
Analog Display: 50-500 µA moving coil indicator

#### • ANALOG OUTPUT:

Level: 1 VDC with reading of 1000  
Output Resistance: 100 ohms, nominal  
Accuracy: ±(accuracy of range + 2% of meter F.S.)

#### • REFERENCE CONDITIONS:

Temperature: +25°C ±1°C  
Relative Humidity: 30 to 80%  
Atmospheric Pressure: 575 to 800 mmHg

#### • POWER REQUIREMENT:

AC Operation or Battery Charging: 117 VAC or 234 VAC ±10% (check rear panel designation) 50 to 400 Hz  
Battery Operation: Four nickel-cadmium "C" size rechargeable cells (not supplied) GE Cat. No. GCT1.5SB or equivalent; each cell rated at 1.25V, 1.5 ampere-hours

Operation Time (continuous with fully charged battery): 5 hours nominal  
Recharge Time (function switch in "BATT CHRG ONLY" position): 16 hours nominal  
Recharge Time (while instrument is in operation): 30 hours nominal

#### • TEMPERATURE RANGE:

Operating: 0°C to +50°C  
Storage: -40°C to +60°C

#### • WEIGHT (with batteries):

4.5 lbs. (nominal)  
(without batteries): 4.0 lbs. (nominal)

#### • DIMENSIONS:

7.2" high, 5.4" wide, 3.75" deep (not including panel controls)

### DC VOLTAGE

Range	Maximum Indication	Input Impedance	Overload Protection
200 mV	199.9 mV	≥ 100MΩ	350V
2V	1.999V	≥ 1000MΩ	350V
20V	19.99V	10MΩ	1100V
200V	199.9V	10MΩ	1100V
1000V	1100 (max. input)	10MΩ	1100V

Accuracy: (from +15°C to +35°C) ±(0.25% of reading + 1 digit)

Input Bias Current: 7 nA maximum at reference conditions

Resolution: 100 µV on 200mV range

Overrange Capability: Linear to 250 counts beyond maximum indication (except on 1000V range, where "overrange" is an overload)

Temperature Coefficient: (from 0°C to +50°C) ±(0.025% of reading + 0.1 digit)/°C

Full Scale Step Response: 2 seconds (to 2,000 counts) (to rated accuracy)

Normal Mode Rejection: 35 dB minimum at 60 Hz

Common Mode Rejection: 80 dB minimum at 60 Hz with 1kΩ unbalance  
1000 dB min. at DC with 1kΩ unbalance

### AC VOLTAGE (Average-sensing, RMS-Calibration Sinewave)

Range	Maximum Indication	Input Impedance	Overload Protection
200mV	199.9mV	1MΩ and 150 pF	350V RMS
2V	1.999V	1MΩ and 150 pF	350V RMS
20V	19.99V	1MΩ and 150 pF	600V RMS
200V	199.9V	1MΩ and 150 pF	600V RMS
600V	600V (max. input)	1MΩ and 150 pF	600V RMS

Accuracy: (from +15°C to +35°C) ±(0.5% of reading + 1 digit), 40 Hz to 1.0 kHz

±(1.0% of reading + 1 digit), 1.0 kHz to 10 kHz

±(2.0% of reading + 2 digits), 10 kHz to 20 kHz

Resolution: 100 µV on 200mV range

Overrange Capability: Linear to 250 counts beyond maximum indication (except on 600V range, where "overrange" is an overload)

Full Scale Step Response: 5 seconds (to 2,000 counts) (to rated accuracy)

Temperature Coefficient: (from 0°C to +50°C) ±(0.05% of reading + 0.1 digit)/°C

### RESISTANCE

Range	Maximum Indication	Short Circuit Current	Full Scale Voltage	Max. Open-Circuit Voltage	Overload Protection
200Ω*	199.9Ω	420µA	100mV	150mV	250V RMS**
2kΩ*	1.999kΩ	42µA	100mV	150mV	250V RMS**
20kΩ	19.99kΩ	10µA	200mV	10V	250V RMS
200kΩ	199.9kΩ	10µA	2V	10V	250V RMS
2MΩ	1.999MΩ	1µA	2V	10V	250V RMS
20MΩ	19.99MΩ	100nA	2V	10V	250V RMS

Accuracy: (from +15°C to +35°C) 20kΩ, 200kΩ and 2MΩ ranges: ±(0.5% of reading + 1 digit)

200Ω & 2kΩ ranges: ±(0.7% of reading + 2 digits)

20MΩ range: ±(1% of reading + 2 digits)

Resolution: 0.1 ohm on 200Ω range

Overrange Capability: Linear to 250 counts beyond maximum indication, except on 200Ω and 2kΩ ranges

Temperature Coefficient (from 0°C to +50°C) ±(0.5% of reading + 1 digit)/°C

Full Scale Step Response: 2 seconds (to 2,000 counts), except on the 20MΩ range, which is 5 seconds

\*Low Power Ohms: 1. Maximum Open Circuit Voltage = 150mV

\*\*Fuse Protected 2. Maximum Power Dissipated in Unknown = 100µW

### DC CURRENT

Range	Maximum Indication	Full Scale Voltage Drop	Overload Protection
200µA	199.9µA	200mV	3mA
200µA	199.9µA	200mV	25mA
2mA	1.999mA	200mV	1/2 Amp*
20mA	19.99mA	200mV	1/2 Amp*
200mA	199.9mA	200mV	1/2 Amp*
2A	1.999A	200mV	3 Amps
10A	10.00A (max. input)	100mV	10 Amps

Accuracy: (from +15°C to +35°C) ±(0.5% of reading + 1 digit) except on 2A and 10A ranges, which are ±(1.0% of reading + 1 digit)

Resolution: 10 nA on 20µA range

Overrange Capability: Linear to 250 counts beyond maximum indication (except on 10A range, where "overrange" is an overload)

Full Scale Step Response: 2 seconds (to 2,000 counts) (to rated accuracy)

Temperature Coefficient: (from 0°C to +50°C) ±(0.03% of reading + 1 digit)/°C

\*Fuse Protected

### AC CURRENT (40Hz to 10kHz)

Range	Maximum Indication	Full Scale Voltage Drop	Overload Protection
200µA	199.9µA	200mV	25mA
2mA	1.999mA	200mV	1/2 Amp*
20mA	19.99mA	200mV	1/2 Amp*
200mA	199.9mA	200mV	1/2 Amp*
2A	1.999A	200mV	3 Amps
10A	10.00A (max. input)	100mV	10 Amps

Accuracy: (from +15°C to +35°C) ±(1.0% of reading + 1 digit) except on 2A and 10A ranges, which are ±(2.0% of reading + 2 digits)

Resolution: 100 nA on 200µA range

Overrange Capability: Linear to 250 counts beyond maximum indication (except on 10A range, where "overrange" is an overload)

Full Scale Step Response: 5 seconds (to 2,000 counts) (to rated accuracy)

Temperature Coefficient: (from 0°C to +50°C) ±(0.05% of reading + 1 digit)/°C

\*Fuse Protected

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

E.I. 187C WOODLAWN WANDERER  
(E.U. 60 - Cells & Tissues Holding Unit)

Purpose

This device maintains living cell cultures, provides for phase-contrast and time-lapse motion pictures of living cells, and fixes certain cultures as prescribed time intervals.

Requirements

The Woodlawn Wanderer was used to carry out the S015 experiment aboard Skylab. Its major objectives were:

- a. To maintain living cell cultures by supplying them with proper nutrients and temperature, 36°C.
- b. To produce two phase-contrast time-lapse motion pictures of living cells for 28 days.
- c. To fix a group of the cultures at predetermined intervals.
- d. To return intact some of the cultures of living cells for subsequent subculture and preservation. These cultures were maintained at approximately 22°C after the first 12 days of the mission.

Hardware Status

Rating: Space Qualified.

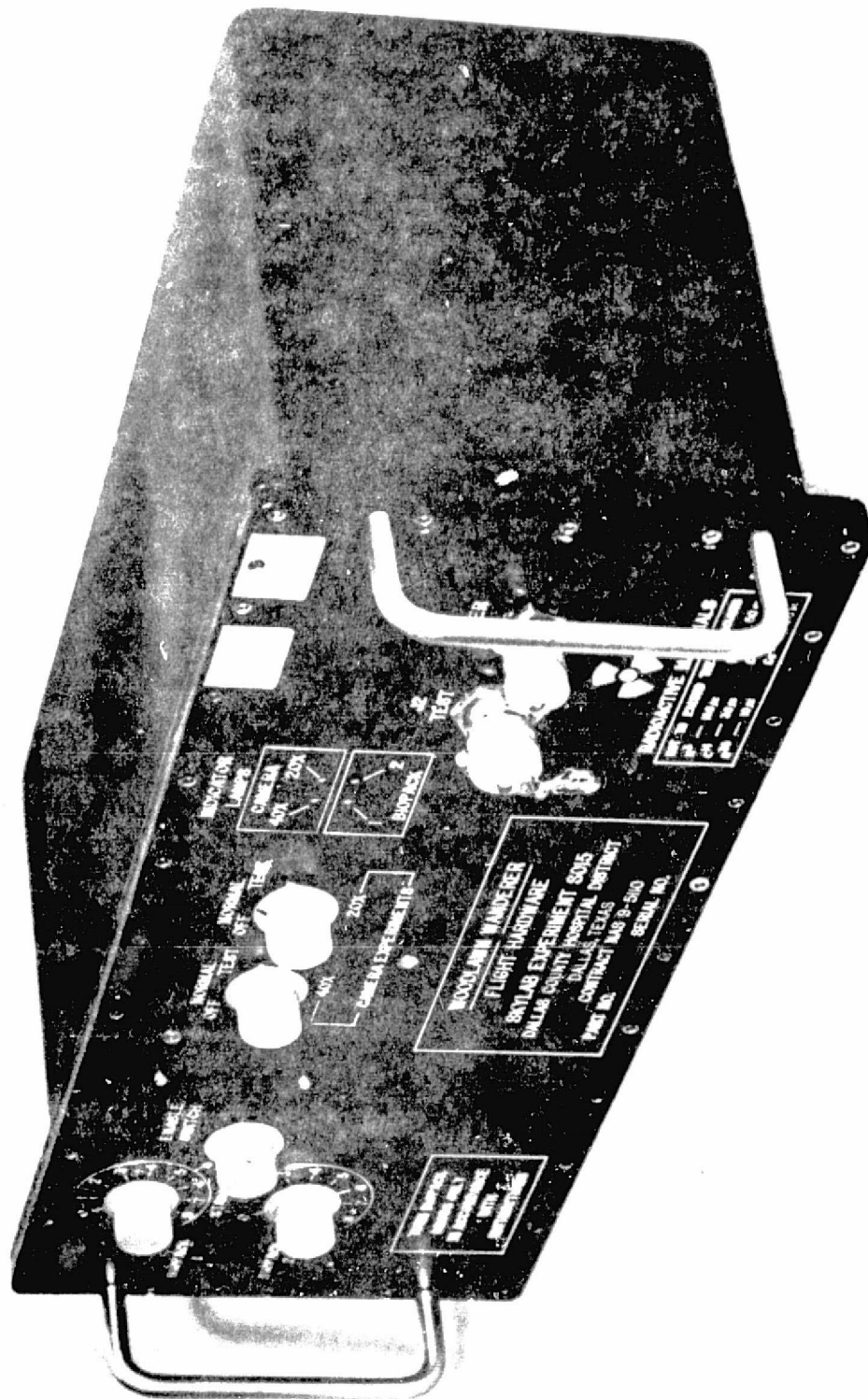
The Woodlawn Wanderer was developed by the Laboratories for Cell Research, Woodlawn Hospital, Dallas County Hospital District, Dallas, Texas. Three flight articles are presently in bonded storage and can be used for future missions. In addition, the hardware is presently undergoing modification in order to extend its capability for different type of cultures, longer missions, different procedures, etc.

Technical Description

Weight:	10 kg (4.5 lb)
Dimensions:	40 × 19 × 17 cm (15.7 × 7.5 × 6.7 in.)
Volume:	12.9 dm <sup>3</sup> (0.46 ft <sup>3</sup> )
Power:	15 watts, 28 v d.c.
Heat Rejection:	15 watts
Data Management:	Data is recorded on a film pack internal to unit.

Development Time: 12 months.

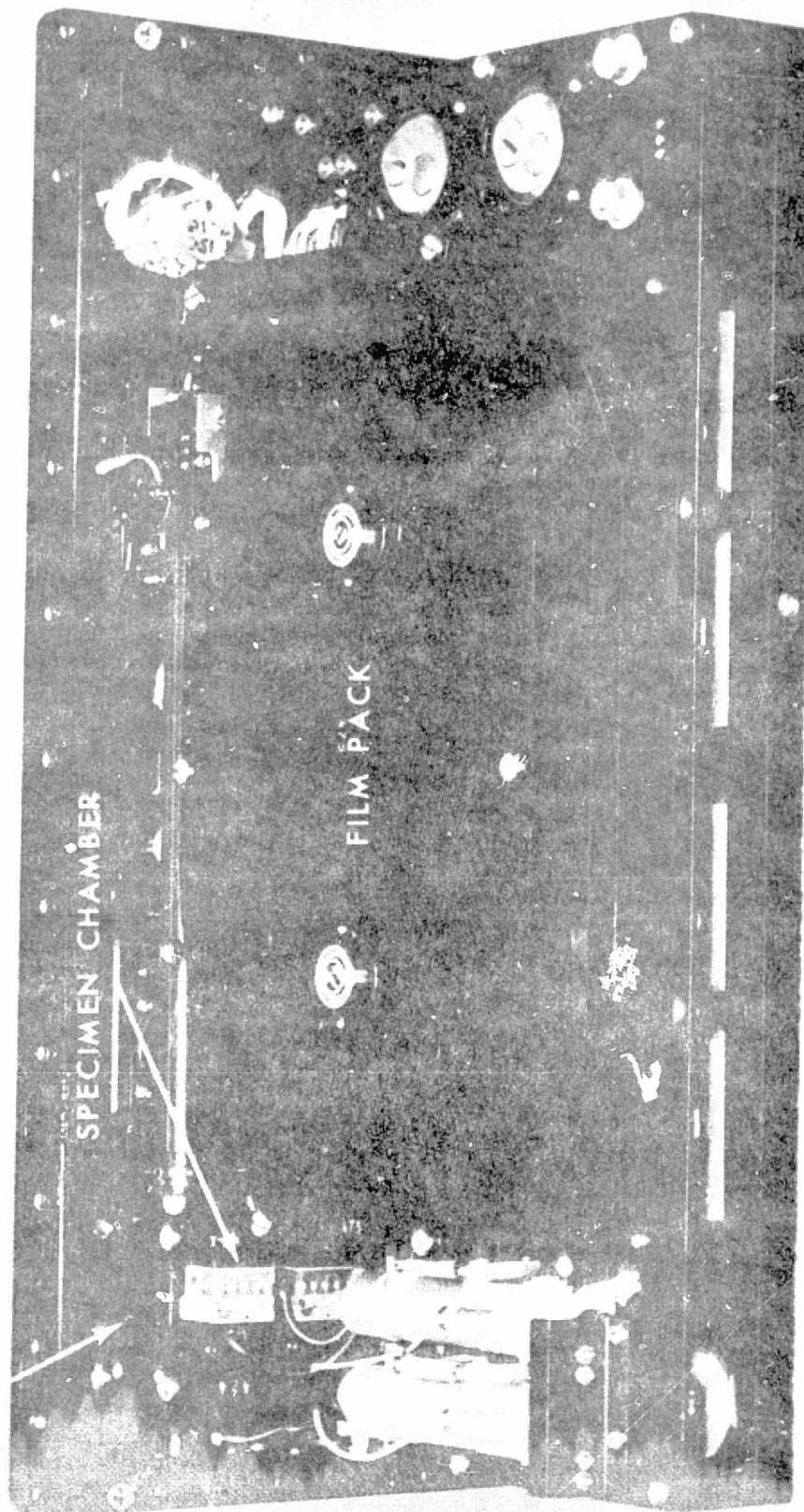
SO15 EFFECT OF ZERO G ON SINGLE HUMAN CELL



Woodlawn Wanderer

SO15 EFFECT OF ZERO G ON SINGLE HUMAN CELL

40X MICROSCOPE



Woodlawn Wanderer (Internal View)

E.I. 188 WORK AND SURGICAL BENCH  
(E.U. 4 - Preparation and Preservation Unit)

Purpose

To provide an enclosed bench area for work and surgery requiring atmospheric isolation from the cabin.

Requirements

The Dedicated Life Sciences Laboratory proposed for future Shuttle missions requires that multipurpose equipment be designed in order to accommodate, in a minimum area, a maximum number of functions. Certain life sciences experiments define the need for a hood for chemical experiments that require the exhausting of noxious gases, for a microbiological transfer area that maintains a clean environment for transfers while containing possible pathogens in an enclosed area, and for a surgery area that will keep skin antigens, hair, and debris contained while protecting the animal from possible pathogens present in the cabin air. The following general requirements would apply to the work/surgical bench:

1. The work area should be large enough for surgery on macaque monkeys, but also suitable for procedures on various types of smaller vertebrates, plants, etc.
2. Air flowing between the cabin and the bench interior for ventilation purposes should be thoroughly filtered for bacteria and contaminant gas removal.
3. The bench should contain provisions for glove parts, water, electrical power, vacuum, clean-up, lighting, pressurized gases, equipment restraints, waste handling, etc., on an as-needed basis.

Hardware Status

Rating: SRT

A work and surgical bench prototype has been built at NASA (ARC) (Principal Investigator is Dr. Paul Callahan, 415/965-5755). The prototype was not a flight prototype but more of a concept verification test unit. It weighed about 318 kg (700 lb) and consumed several kilowatts of power. A modified version would be required for use in the life sciences laboratories.

Technical Description

The bench, as conceived herein, would include a rigid hood with large transparent windows. Both glove and arm seal ports would be available for use. Also, one side of the hood would be capable of being opened up for organism or equipment insertion and removal. A small airlock would also be available for the transfer of smaller items. Internal laminar air flow would be used to move debris and wastes to a collection site. The following properties were estimated for a flight-type unit:

Weight:	136 kg (300 lb)
Dimensions:	100 cm W × 70 cm H × 60 cm D (39.4"W × 27.6"H × 23.6"D)
Volume:	420 dm <sup>3</sup> (14.8 ft <sup>3</sup> )
Power:	1000 watts (type of power tbd)
Heat Rejection:	1000 watts
Data Management:	tbd
Location:	Access to the front and at least one side is required. Organisms must be transferred from their holding units to the bench.
Interfaces:	Many research procedures will be performed on the work and surgical bench. Therefore, it must be compatible with a number of the laboratory E.I.s. Some of these E.I.s will be used within the hooded part of the bench and will have to be compatible with bench hold-downs, etc. Other E.I.s will require hard connection to the bench in the form of structural ties, plumbing interconnections, wire connections, etc. The E.I.s which may require some interface consideration include the following: <ol style="list-style-type: none"> <li>1. The camera equipment (E.U. 1).</li> <li>2. Various data management E.I.s such as couplers, oscilloscope, numeric read-out, etc. (E.U. 2).</li> <li>3. Coolant loop liquid (E.I. 51F, E.U. 3).</li> <li>4. Equipment restraint device (E.I. 70C, E.U. 3).</li> <li>5. Gas supplies (E.I. 93A, E.U. 3).</li> <li>6. Glove box (E.I. 96, E.U. 4).</li> <li>7. Liquid storage &amp; dispensing system (E.I. 114G, E.U. 3).</li> <li>8. Manifold, vacuum (E.I. 118I, E.U. 3).</li> <li>9. Plumbing (E.I. 141A, E.U. 3).</li> <li>10. Recorder, Strip Chart (E.I. 150A, E.U. 1).</li> </ol>

E.I. 188 (Cont'd)

Subsystems within the Spacelab which will interface with the Work and Surgical Bench will include the CDMS, EPS, and TCS.

Development Time: 24 months.